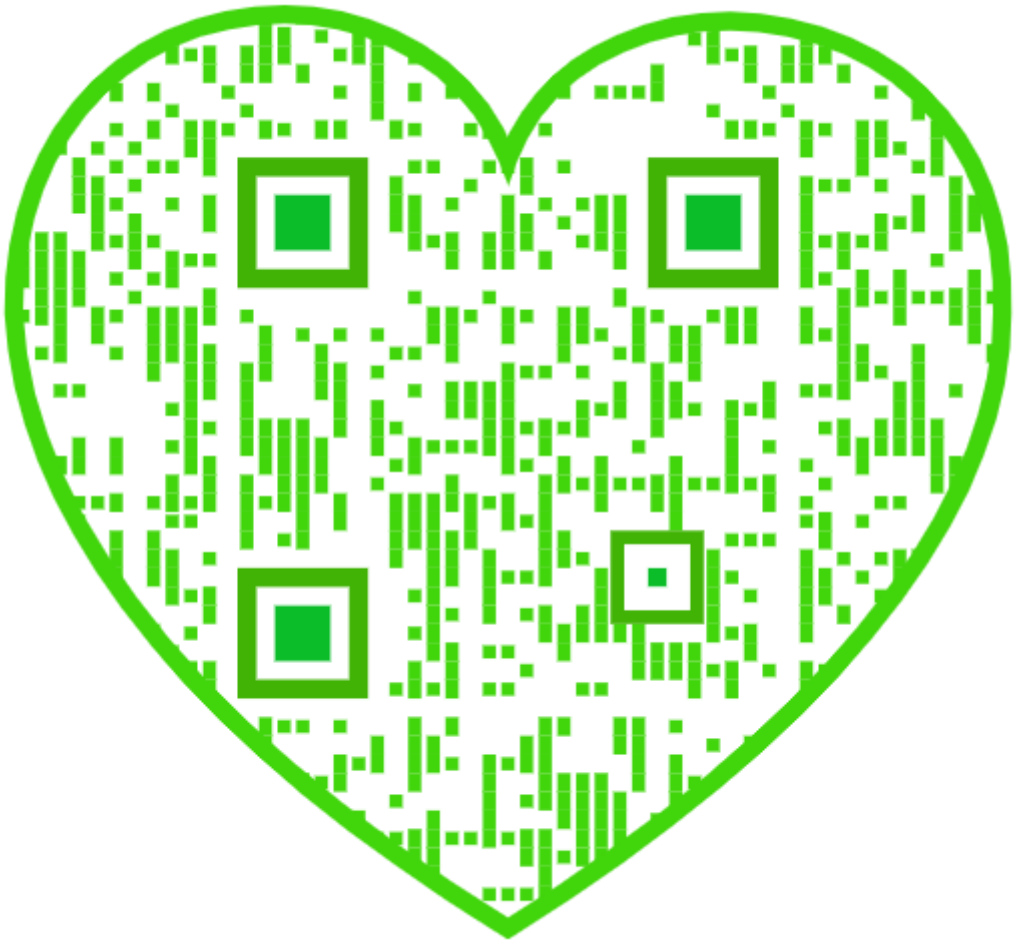

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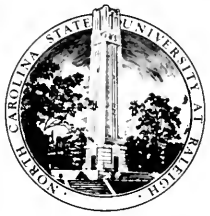

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A PRACTICAL MANUAL.

BY

GEORGE DUERR,

DIRECTOR OF THE BLEACHING, DYEING, AND PRINTING DEPARTMENT AT THE ACCRINGTON AND BACUP TECHNICAL SCHOOLS; CHEMIST AND COLOURIST AT THE IRWELL PRINT WORKS.

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PREFACE.

THE subject-matter of this manual consists mainly of the course of lectures (in a form sufficiently condensed to meet the requirements of the publishers) given annually to classes of Students studying the Technology of Bleaching and Calico-Printing under the Author's direction. Although the subject is necessarily treated technically, yet the aim throughout has been to make it as clear, concise, and simple as is consistent with a thorough scientific explanation of the principles involved. The book is not intended as a mere source of "cram" for an examination, but as a reliable and practical guide to the young bleacher and calico-printer. In this the Author has received much valuable assistance from Mr. William Turnbull, who is well known as a practical calico-printer.

The patterns introduced are not highly-finished, elaborate designs, intended to advertise the firms supplying them, but are of the most simple kind possible, and intended to illustrate the various stages of bleaching and calico-printing. The recipes given are not a collection culled from other books, but are those by which the accompanying patterns were actually produced, or which are known to be reliable and practicable.

Chemical equations are freely used for the purpose of illustrating methods of preparing the various mordants, dyestuffs, and other substances necessary for the production of the colours, and the Student is strongly advised to make himself familiar at the outset with the general principles of chemistry and physics.

G. D.

STACKSTEADS, *December*, *1895*.

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BLEACHING
AND
CALICO-PRINTING.

CHAPTER I.—BLEACHING.

COTTON.

Cotton consists of the fibres which are attached to the seeds of the cotton plants, a branch of the order of mallow worts or Malvaceæ; to this branch the generic name of *Gossypium* is given. There are several species of cotton plants known, the principal being *Gossypium barbadense*, which yields the Sea Island and other American varieties of cotton; *Gossypium Peruvianum*, which yields the South American varieties of cotton; *Gossypium herbaceum*, which yields the short fibre varieties of Indian, China, and Asiatic cotton; and *Gossypium arboreum*, which yields the long-fibred Egyptian and Asiatic cottons.

The cotton fibre, when seen under the microscope (see Fig. 1), is essentially a tube of a more or less spiral shape, and may be likened to

Fig. 1.—Ripe cotton fibre.

a ribbon with thick edges twisted on itself. The length of the cotton fibre varies considerably; in Sea Island cotton it reaches nearly 2 inches, but in Indian cottons it is often met with under an inch in length. The diameter is small, and ranges from 0·00046 to 0·001 of an inch.

The cotton fibre will support a weight of from 84 to 164 grains, the fibres having the largest diameters being usually the strongest.

As stated above, and shown in Fig. 1, the cotton fibre when viewed under the microscope appears to resemble a twisted ribbon, the edges of which are thicker than the middle portions. This twisted appearance is found to be more highly developed in ripe fibres than in unripe fibres. In the latter case the fibres are full of sap, which on drying out causes the fibres to collapse and assume a flat shape, which

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is seen in Fig. 2. In the centre of the fibre is a tube which is much more visible in ripe than in unripe fibres. It is worth noting that unripe fibres do not attract dye so well as the ripe fibres.

Composition.—Cotton in its natural state is principally composed of cellulose, and is accompanied by a small amount of natural impurities which average about 4 or 5 per cent.

The cellulose of cotton is a white substance belonging to the class of carbo-hydrates—that is, a class of organic bodies consisting of three elements, viz., carbon, hydrogen, and oxygen, the two latter being present in the proportion in which they form water, namely, 1 part of hydrogen to 8 parts of oxygen by weight—so that we may look upon cellulose as a sort of chemical combination of carbon and water: hence the term "carbo-hydrate."

Action of Chemicals.—The empirical formula of cellulose is $C_6H_{10}O_5$. It is insoluble in ordinary solvents, water, alcohol, ether, &c.; but it dissolves in strong sulphuric acid, also in an ammoniacal solution of cupric hydrate. Cold dilute mineral acids have no action, but if allowed to dry upon the cotton they gradually become concentrated, and then tender the fibre. The same corrosive action

Fig. 2.—Unripe cotton fibre.

takes place if cotton impregnated with such acids is heated. The process of "extracting" or "carbonising" woollen rags containing cotton (*i.e.*, destroying and removing the cotton) by means of sulphuric or hydrochloric acids is founded on this fact. By a brief immersion in a mixture of 1 part strong sulphuric acid and 1 part water, cellulose in the form of paper is converted into vegetable parchment. By the action of a mixture of strong nitric acid and sulphuric acid, cellulose is converted into nitro-cellulose; a compound in which nitric peroxide has replaced some of the hydrogen of the cellulose. Gun-cotton is one form of nitro-cellulose, and soluble pyroxyline, a substance used in the preparation of collodion, is another. Acetic, tartaric, and citric acids have little or no action on cotton; a cold solution of oxalic acid has no action, but if cotton be heated therewith to 100° C., it is more or less "tendered"; hence care must be taken when using steam colours containing oxalic acid for printing calico. Cotton is not so readily affected by alkalies as it is by acids, and in this respect is just the reverse of wool. Cotton may even be boiled for several hours with weak caustic alkalies, if care be taken that it is immersed below the surface of the solution; but under some circumstances the combined action of steam, air, and alkalies, especially lime, will tender cotton; and such conditions must be guarded against during certain of the operations of bleaching. The action of strong solutions of caustic

soda or potash is very remarkable. If a piece of calico be steeped for a few minutes in a solution of caustic soda of about 50° Tw. (sp. gr. 1·25), it assumes quite a gelatinous and translucent appearance; when taken out and washed free from alkali, it is found to have shrunk considerably and become much closer in texture. If a single fibre thus treated be examined under the microscope it is seen to have lost all its original characteristic appearance; it is no longer flat and spirally twisted, but seems now to be thick, straight, and transparent. A transverse section shows it to be cylindrical, while the cell walls have considerably thickened, and the central opening is diminished to a mere point (Fig. 3).

Fig. 3.—Sections of Ripe, Unripe, and Mercerised cotton fibre.

Cotton thus treated is said to be "mercerised;" mercerised cotton has a greater attraction for colouring matters than ordinary cotton. Dilute solutions of hypochlorites—bleaching liquors—do not act injuriously when cold; but stronger solutions, especially in contact with air, convert cotton into what has been called by Witz, oxy-cellulose.

Many salts, such as chloride of tin, sulphate of alumina, nitrate of lead, &c., will tender the cotton fibre, especially if it be heated with them, as is sometimes done in the production of steam colours in calico-printing.

Cotton has a strong affinity for tannin; advantage is taken of this fact for the purpose of mordanting cotton with either tannin or tannin materials, like sumach, divi-divi, chestnut, &c., for dyeing with the basic colours.

Cotton has but little affinity for colouring matters. With a few of the natural dyestuffs, turmeric, safflower, and annatto, it will unite directly. Of the coal-tar colours, cotton has no affinity for the acid and azo colours in general. Of the basic colours, saffranine and methyl violet are the only ones which possess any sort of affinity for cotton, and even these will only produce pale shades. For the so-called Congo or direct cotton colours, of which Congo-red was the first commercial representative, cotton has a very powerful affinity, and with these dyestuffs produces some very deep and fast shades. What particular feature in the composition of these colours gives them this property of direct combination with cotton, is not yet satisfactorily explained.

BLEACHING.

Impurities.—By natural impurities we understand everything present in the fibre except cellulose—that is to say, cotton wax, a small quantity of margaric acid, pectic acid, albuminous matter, and colouring substances. The artificial impurities—accidental or inten-

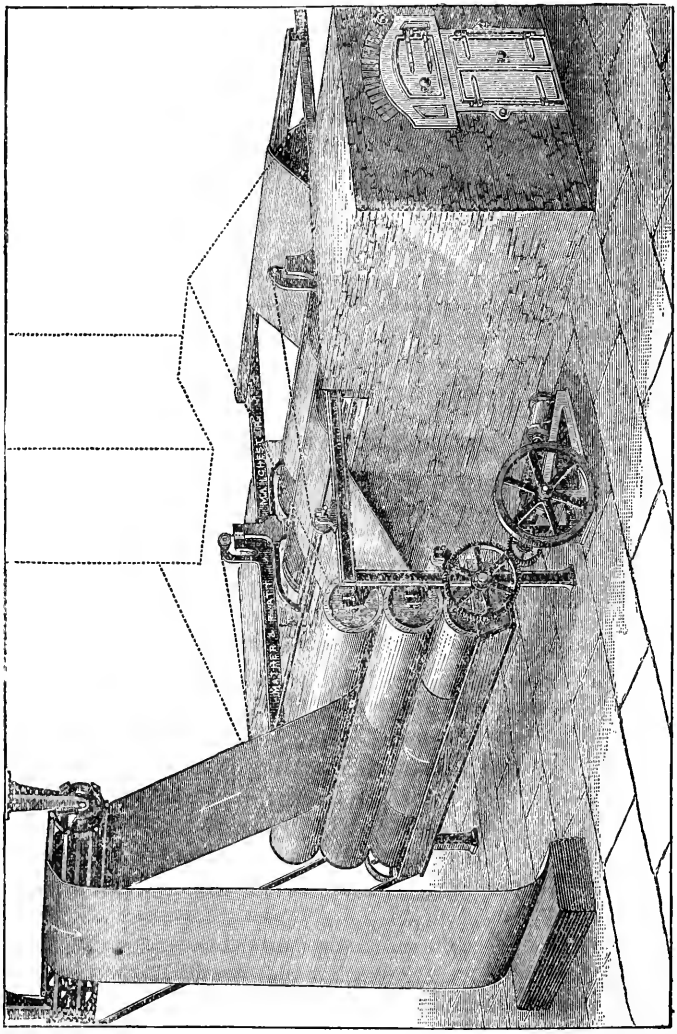

Fig. 4.—Double plate-singeing machine, showing draw bowls and damping trough.

tional—may amount in woven goods to 20 or 30 per cent. They consist of grease, starch, and other ingredients used in the sizing, besides oil from the machinery. The removal of these impurities so that nothing but pure white vegetable fibre may remain is the result

sought in the highest grade of bleaching—technically known as the "madder bleach"—because it was first applied to goods to be printed with madder colours. It is also used for cloths which are to receive light and pure colours. For goods that are to be dyed black or other dark shades, a less thorough treatment will be sufficient. For goods

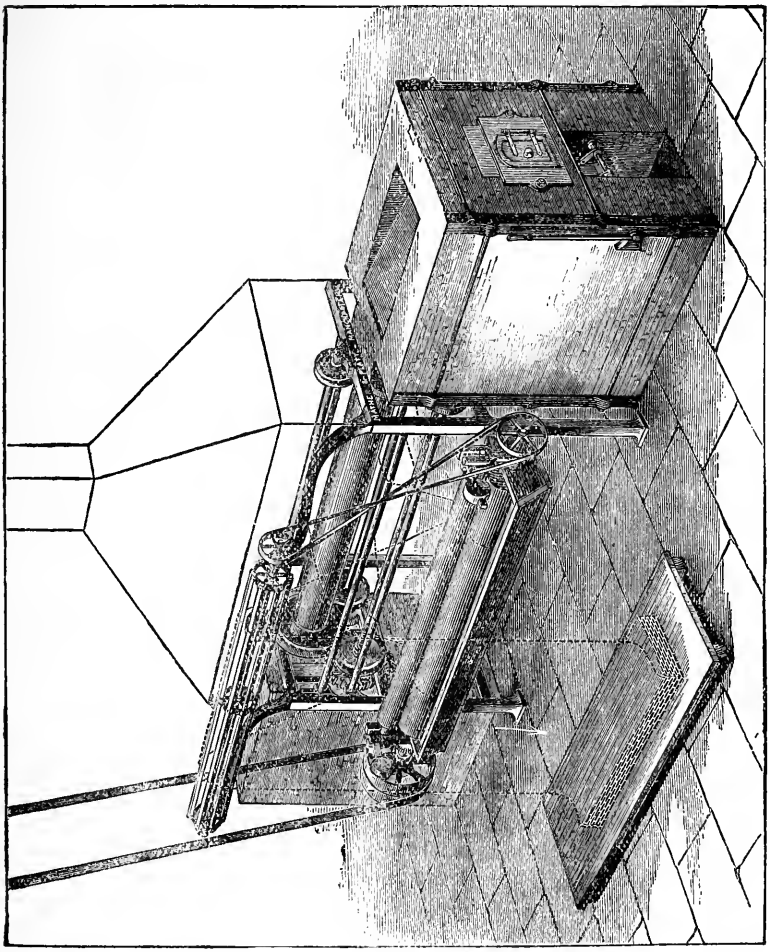

Fig. 5.—Revolving plate-singeing machine; the advantage of the revolving plate is that a red-hot surface is always presented to the cloth.

that are to remain white, a special bleach called a "market bleach" is given.

Singeing.—Previous to the bleaching operations proper, piece goods are usually stamped with gas tar, or some other substance capable of resisting the bleaching process, in order that they may be afterwards identified. After being marked, the pieces are stitched together, end to end; they are then passed through the singeing machine (shown in Figs. 4 and 5) in order that the fine loose down

may be burned off the surface of the cloth, as this down interferes with the production of a fine impression in the printing process. The singeing is performed by rapidly passing the cloth in the open width over red-hot copper plates or between rows of gas flames; formerly all goods were singed by the hot plate method, but lately gas singers have come more into use, especially for the lighter and thinner cloths. The singeing plate must be kept at a very strong red heat, and in order to do this a very good fire must be kept up immediately under the plate; while the cloth is drawn rapidly over one or more of these hot plates by means of rollers, a frame with iron bars depresses the cloth tightly upon the hot plate, and one of the greatest difficulties with the plate singeing machine is to get the cloth to press evenly upon all parts of the plate, so that one part of the cloth may not be burned more than another, otherwise the cloth will show streaks after it has been dyed a plain shade; of course this difficulty is not experienced with the gas singeing machine, which consists essentially of one or more rows of Bunsen burners, through which the cloth is drawn at a rate suitable for the kind of cloth to be singed. After passing over the singeing plate or between the gas burners, the cloth should immediately pass through a water trough, or else through a pair of wet draw bowls, in order that any sparks may be at once extinguished.

Grey Wash.—The pieces are drawn direct from the singeing house guided by means of glazed earthenware rings, "pot eyes," through the washing machine and plaited down, "in pile," on a stillage in the bleach house, where they are allowed to lie a few hours to soften. This, the first stage in bleaching proper, is called the "grey wash," and the pieces previously in the open width have now assumed the rope form, which they will retain throughout the whole of the bleaching operations.

The Lime Boil.—The second process in bleaching, called the "lime boil," is a very important one. As already stated, the cotton fibre is made up of cellulose and a small quantity of other substances, such as wax, pectose, and colouring matters; now it is very probable that the object of the lime boil is to break up the combination of the wax and the cellulose; for it has been found in practice that nothing is so effective for the removal of the waxy coating from the cotton fibre as boiling with lime. The lime for this purpose should be freshly burned and well slaked; if the lime is old it will have absorbed carbonic acid from the atmosphere, and this will render it unfit for bleaching purposes. It will also be found that lime which has been exposed to the atmosphere cannot be slaked like freshly-burned lime. The lime should be well slaked; for badly-slaked lime will be in a very porous condition, almost like sand; in this porous condition it very quickly absorbs carbonic acid gas from the atmosphere, and so becomes spoiled for the purpose of bleaching. On the other hand, if the lime be good and well slaked, it will have the consistency of fat, in which

state it is very impervious, so that the carbonic acid gas cannot enter into and combine with it, and in this condition it will keep good for months. I believe this exclusion of the carbonic acid to be a very important matter, and one which (owing to the invisible nature of the gas) is liable to be overlooked by the workmen. In fact, so deceptive is the appearance, that even an experienced chemist cannot distinguish between good and bad lime by merely looking at it; he must apply some chemical test.

Testing the Lime.—As stated, the lime may have absorbed a considerable amount of carbonic acid gas, either before or after being slaked, and this can only be found by treating the sample with nitric acid in a suitable apparatus, so that the amount of evolved carbonic acid may be determined by weighing. The form of apparatus most convenient for this purpose (shown in Fig. 6) consists of two light glass bottles, of about half a pint capacity, with perforated india-rubber stoppers fitted to each. The bottles are connected by a glass and indiarubber tube, the extra hole in each stopper being plugged with a solid glass plug. The amount of lime which should be weighed off is about 10 grammes; this, after weighing, is slaked with water, and then poured into bottle B. Next, a tube, holding about 100 c.c., is about two-thirds filled with moderately strong nitric acid (1 part acid, 1 part water), and is then carefully lowered into bottle B, taking care not to spill any acid from the tube. The tube must be of such dimensions as to rest in the bottle just in the manner shown in Fig. 6, without being able to fall over. Bottle A contains strong sulphuric acid up to about one-third of its capacity. The india-rubber tubes and stoppers are now attached to both bottles, so as to connect them. Both bottles and contents are next carefully weighed together, and after weighing, bottle B is tilted on one side, so as to cause the acid to run out of the test tube on to the lime. This will cause the whole of the lime to dissolve, but no gas will be given off if it is quite pure. However, as the lime is not likely to be quite pure, it is almost certain there will be more or less gas given off, and this gas will pass out of bottle B, through the tube into bottle A, and bubbling through the sulphuric acid, will finally escape through the small hole in the stopper, the plug of which has been previously withdrawn. After about ten minutes, when all action has ceased, the bottles must be placed in a dish of hot water; a small bit of glass tube (about 2 inches long), to which is attached 1 foot of indiarubber tubing, is inserted air-tight into the hole of the stopper of bottle A,

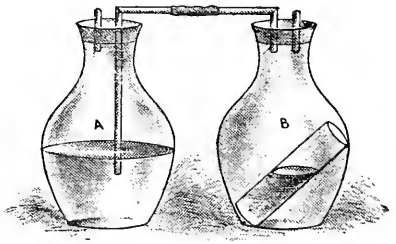

Fig. 6.—Apparatus for testing lime.

the other end being placed in the mouth; suction is applied, and at the same moment the stopper of bottle B is removed; this will cause a current of air to be drawn through the apparatus, which will sweep out the whole of the carbonic acid. This being done, the aspiration tube is removed from bottle A, the two glass plugs are replaced, the bottles removed from the water, allowed to cool, and dried; the plugs are then again removed for a moment and replaced.

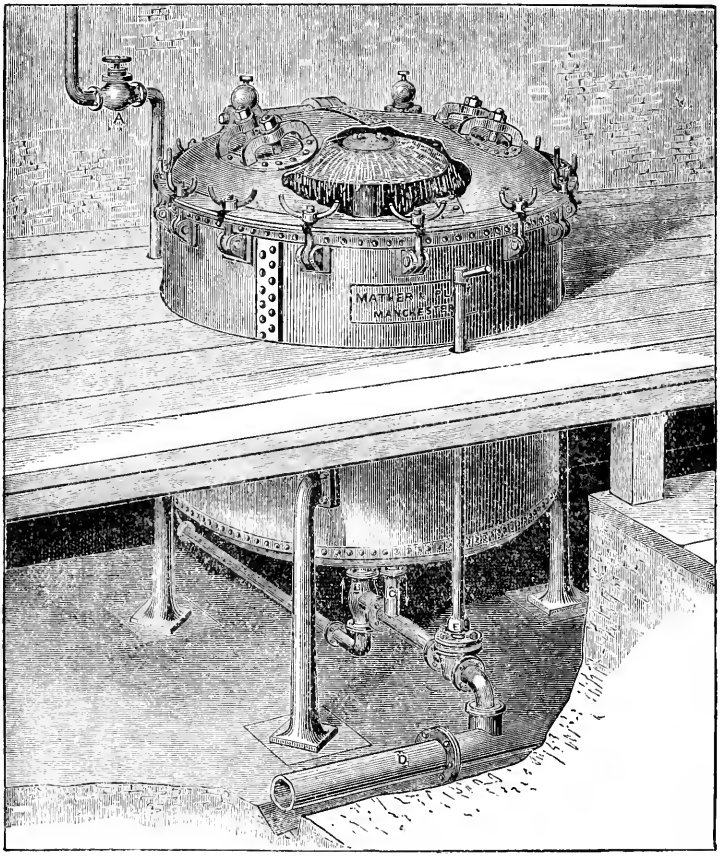

Fig. 7.—Low-pressure kier, which can also be used as an open kier.

The whole apparatus and contents being reweighed, the difference between this and the first weighing is the amount of carbonic acid in the sample of lime. Should this amount to 1 gramme, the lime is not good. This is a very practical and accurate way of testing the quality of the lime.

Slaking the Lime.—Having selected a good sample of lime, it is next well slaked as follows:—Into a rather deep and water-tight pit,

run in water through a trough or pipe, at the same time throwing in lime at a speed sufficient to keep the water in a vigorous state of ebullition, taking care to keep the pieces of lime well raked up from the bottom of the pit, in order that it may all be thoroughly slaked. For every ton of cloth to be bleached, about 1 cwt. of slaked lime

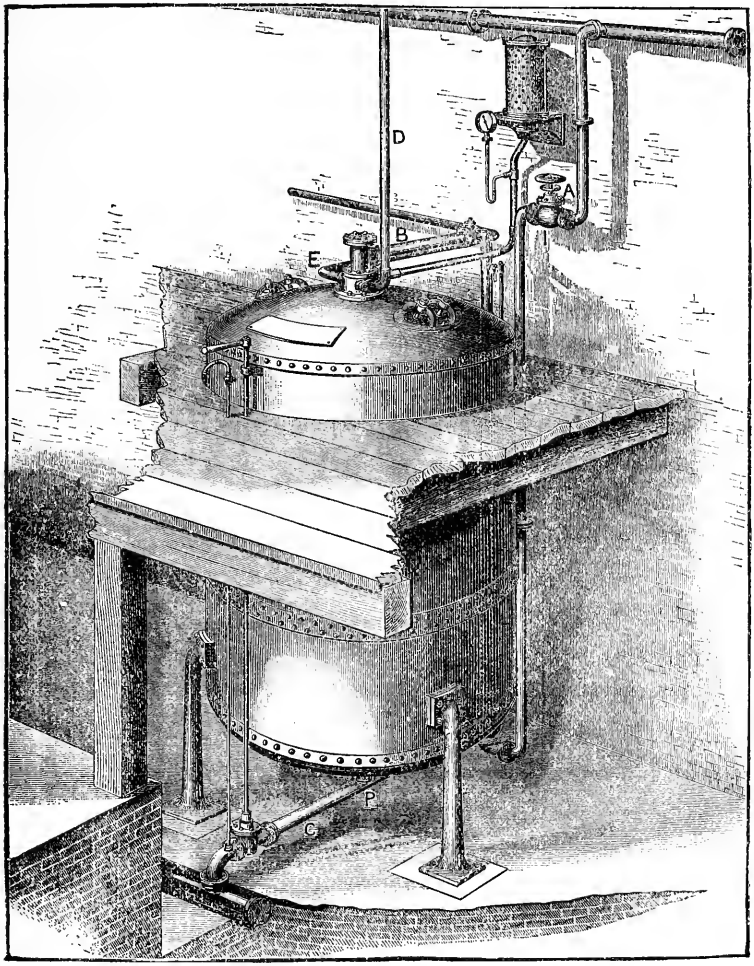

Fig. 8.—High-pressure kier worked by injector.

will be required, and this must be mixed with sufficient water to make it into a thin milky liquid, which must be run through a sieve into the liming box, as great care must be taken that no large particles of solid matter may come in contact with the cloth; otherwise much damage may be done to the cloth in the liming machine.

Cases have occurred where, in consequence of a piece of crock or a nail having got into the squeezing bowls of the liming machine, many hundreds of yards of the cloth were damaged before it was detected.

Bowking.—Having been run through the milk of lime in the liming machine, the cloth is passed on into the kier, where it will be subjected to a "bowking" or boiling. In filling the kier with cloth, care must be taken that it is packed in very systematically; this is done by boys who go into the kiers when they are being filled, and with their hands, and wooden clogs on their feet carefully tread down the cloth in such a way that it will not get tangled during the boiling process. The quantity of lime water must be regulated to the amount of cloth in the kier, neither so much that the goods will be floating about, nor so little that they may get dry, and so become lime-burned. The time required to complete the lime boil will depend upon the kind of kier and the pressure; in closed kiers worked at a pressure of 50 lbs. the boiling may be completed in 6 or 8 hours; in low-pressure kiers, worked at about 10 lbs., twelve to sixteen hours may be required; with open kiers, twenty-four or even thirty hours may be given (see Figs. 7 and 8). After the goods have been properly boiled, the waste liquor is run off from the bottom of the kier, and the cloth is drawn by the draw bowls of the washing machine from the kier. At the same time much of the lime and dirt is removed from the cloth during its passage through the washing machine; but as only a portion of the lime can be removed in this way, the cloth is next subjected to a treatment with weak acid called the "grey sour."

Grey Souring.—The acid generally used for this purpose is hydrochloric at from 1° to 2° Tw.; this acid, usually called "salts," is preferred, as it is cheap and forms a very soluble salt with the lime, viz., calcium chloride ($CaCl_2$), which can be easily removed from the cloth by a subsequent washing; this washing should be continued until all the acid and calcium chloride has been removed from the cloth. The "Twaddell glass" used for determining the density of liquids is a very useful instrument when we know that we are dealing with pure chemicals, but should the liquids be adulterated, this instrument will neither detect the kind nor the amount of the impurities, and in fact it then becomes a useless or even a very misleading instrument. The best way that I know of for a bleacher to test his salts is as follows:—Take 1 pint of the salts to be tested, add 2 pints of water to it, then weigh off 36½ grms. of the mixture in a small dish or basin; next weigh a piece of marble (any weight from 50 grms. to 500 grms.; it may be obtained from any dealer in analysts' chemicals for about 3d.), carefully drop the weighed piece of marble into the diluted salts in the basin, leaving it there for twelve hours or so; then take out the marble, wash it carefully (so as not to break any bits off) in water, put it into a

warm place for a few minutes to dry, then reweigh it, and if the salts are good the piece of marble will have lost about 5 grms.; if the marble loses much less than this quantity, say only 4 grms., the salts are only four-fifths the strength they ought to be.

Boiling with Soda Ash and Resin Paste.—The next process in the madder bleach is boiling with soda ash and resin paste. This process is just a repetition of the lime boil, only using soda ash and resin paste instead of lime. For every ton of cloth, about 1 cwt. of soda ash and 30 lbs. of resin will be required. It is best to boil these substances together in a pan, with about 100 gallons of water, as in this way the resin will be converted into a kind of soap, soluble in

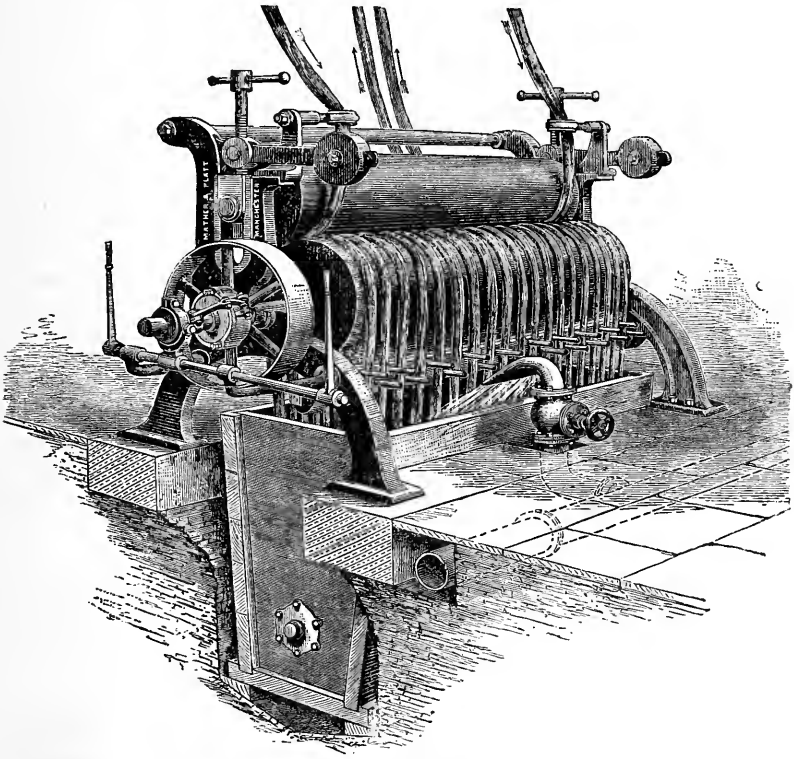

Fig. 9.—Washing, liming, chemicking, and souring machine (ordinary form).

water. This solution of resin is run into the kier along with sufficient water to thoroughly scour the cloth; this scouring will, in the high-pressure kier working up to 40 lbs., be completed in about six hours; but in the low-pressure or open kiers, twelve hours' boiling will be necessary. After a thorough boiling, the spent liquor is run off from the bottom of the kier, the goods are then turned over through the washing machine (see Figs. 9 and 10) and again boiled in a solution of

soda ash (30 lbs. per ton of cloth) without the addition of resin. This second ash boil will only require about half the time necessary for the first, and its object is twofold—first, to still further remove impurities from the cloth, and, secondly, to remove any resin paste which may have been left in the cloth by the first ash and resin boil; as, if any

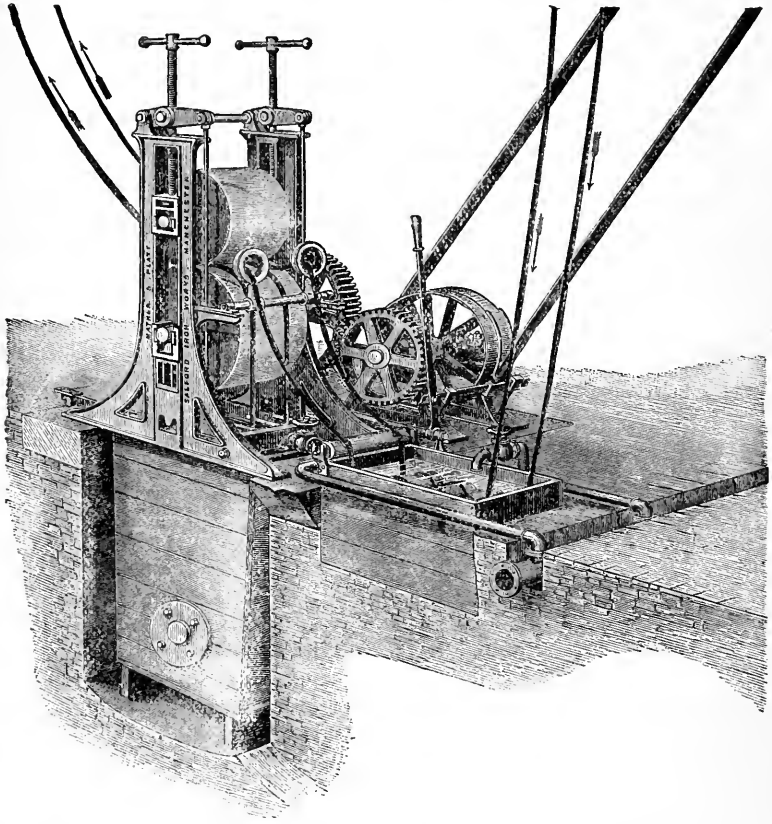

Fig. 10.—Washing machine for market bleach work, or squeezing machine.

resin were left in the cloth when the goods are drawn out of the kier, it might become permanently fixed there by the subsequent treatment which the cloth has to undergo. After the cloth has received another washing, the only impurities remaining in it will be a small amount of colouring matter, and it is in order to remove this last impurity that the cloth is subjected to the process called "chemicking." It will perhaps be as well here to study the theory of the process of bleaching.

THEORY OF BLEACHING.

In the first place, then, it would not do to "chemic" the cloth before it has been bowked with lime and with soda. There are certain impurities in the cloth which must be removed before the chemicking can be done satisfactorily, and these impurities cannot be removed by soda alone, for, although it is not very clear why, it is found in practice that it is best to begin with a lime boil first. It is thought by some that the lime combines with the waxy coating of the cellulose, so as to form a compound of lime and wax; but as this lime compound is not soluble in water, it cannot be removed from the cloth; however, when the lime is removed by souring, it leaves the wax in a state in which it will more readily combine with soda to form a soluble compound. It is not clearly understood what part the resin plays in the "soda-resin boil," but it may be that a kind of triple compound of soda-resin-wax, soluble in water, is formed. It is certain that impurities cannot be removed from the cloth until they have been rendered soluble in water, and it is tolerably certain that during the various bowkings the impurities are rendered soluble, and so removed from the cloth. Previous to the invention of bleaching powder, cloth was always bleached by laying it upon growing grass, in so-called bleachcrofts; the growing grass has the power of decomposing the carbonic acid always present in the atmosphere; the grass retains the carbon of the carbonic acid, but throws off the oxygen in a nascent condition, and oxygen in this state has the power of destroying almost every kind of colouring matter. Of course the action of sunlight would hasten the bleaching very considerably; nevertheless, this was a very slow though sure process of bleaching. The modern process of bleaching is due to the discovery of chlorine gas; not that chlorine gas can really bleach—that is, decolorise colouring matter; but chlorine gas can, under certain conditions, decompose water, and so produce nascent oxygen, which, as just mentioned, has the peculiar property of destroying colouring matter, or bleaching. Now chlorine is only very loosely combined in the chemic, and is, therefore, very easily set free; all acids, even carbonic, will decompose chemic. Take a piece of cloth which has been dyed with coal-tar colour, say alizarine or magenta; dip it into a solution of chemic, and then into some sours, the colour is rapidly bleached, and, at the same time, a strong odour of chlorine gas is given off. Now, every bleacher is aware that there are two objections to this method of bleaching. In the first place, the stench and irritating action of the chlorine are so powerful that no one would be able to stand them for long; and, in the next place, it would be found the cloth would have been more or less tendered by the too rapid action of the chemicals. It is in order to avoid this evolution of chlorine, and consequent tendering, that the cloth is allowed

to lie a few hours after chemicking and before souring off. The action which takes place during that time is as follows:—First, the carbonic acid, always present in small quantities, decomposes a little of the chemic—

$$Ca(OCl)_2 + CO_2 + H_2O = CaCO_3 + 2HClO.$$

The hypochlorous acid thus set free is, in the presence of colouring matter, quickly decomposed into hydrochloric acid and nascent oxygen, thus—$HClO = HCl + O$. The nascent oxygen thus set free immediately decolorises the colouring matter, and the hydrochloric acid produced acts upon another portion of the chemic—

$$Ca(OCl)_2 + 4HCl = CaCl_2 + 2H_2O + 2Cl_2.$$

Now, the chlorine liberated in this reaction has the power, as I have already stated, under certain conditions—*i.e.*, in the presence of colouring matter, of decomposing water, forming hydrochloric acid and nascent oxygen, according to the equation—$H_2O + Cl_2 = 2HCl + O$. This nascent oxygen will bleach more colouring matter, and the hydrochloric acid will decompose more chemic, and so this cycle of reactions will go on until all the cloth is bleached or all the chemic in the cloth is used up; and as this takes place slowly, but continuously, the cloth is not tendered, because it is not subjected to any sudden and violent chemical action; hence, when the cloth is soured off, very little chlorine gas is given off, because there is very little unused chemic in the cloth.

Testing Bleaching Powder.—Commercial bleaching powder consists of a mixture in variable proportions of hypochlorite of lime (the true bleaching agent), calcium chloride, and the hydrate of lime; and its value depends upon the amount of available chlorine contained in it. There are several methods of estimating the amount of available chlorine in bleaching powder, but I think that of Penot will be found as simple and good as any; it relies on the oxidation of arsenious into arsenic acid, thus—

$$As_2O_3 + Ca(OCl)_2 = As_2O_5 + CaCl_2,$$

and is conducted as follows:—A standard solution of $\frac{1}{10}$ normal arsenious acid is prepared by dissolving 4·95 grammes pure sublimed arsenious acid (As_2O_3) and 25 grammes re-crystallised sodium carbonate in 200 c.c. water. The whole is boiled, shaking the glass repeatedly, until dissolved, and then made up to 1-litre solution, which is kept in a well-stoppered bottle for use; 1 litre of this $\frac{1}{10}$ normal solution corresponds to 3·546 grammes chlorine, while 1 c.c. will correspond to ·003546 gramme available chlorine. In conducting tests by this method a specially-prepared paper is used which serves as indicator, and is obtained by moistening ordinary filtering paper with the following preparation:—3 grammes starch are well mixed with 200 c.c. water, with a wooden spatula, until the lumps are all broken up; the

whole is boiled, then 1 gramme of iodide of potassium and 1 gramme of pure carbonate of soda are added, both previously and separately dissolved in a little water; enough water is then added to make up 500 c.c. in all. The filter paper, saturated with this starch and iodide of potassium solution, is then dried, and can be kept in a well-stoppered bottle for use. The first thing to be done in determining the value of a sample of bleaching powder is to bring it into solution, which is best managed as follows :—The sample is well and quickly mixed, and 3·55 grammes weighed, put into a mortar, a little water added, and the mixture rubbed to a smooth cream; more water is then stirred in with the pestle, allowing to settle a little while, then poured off into a litre flask, the sediment again rubbed with water, poured off, and so on repeatedly until the whole of the chloride has been conveyed into the flask without loss, and the mortar washed quite clean; the flask is then filled to the mark with water, well shaken, and 100 c.c. of the milky liquid taken out with a pipette, emptied into a beaker, and the arsenious solution delivered in from a burette until a drop of the mixture, taken out with a glass rod and brought in contact with the prepared starch paper, gives no blue stain. It is easy to see when enough arsenious solution has been added, as the blue spots on the prepared paper become gradually lighter towards the end of the process. The percentage of available chlorine in the sample of bleaching powder or liquid is proportionate to the number of cubic centimetres of arsenious solution used; and as a good sample of bleaching powder contains about 35 per cent. of available chlorine, it will require 35 c.c. of arsenious solution. To a person having no experience in chemical analysis the above may seem a long and complicated process for testing bleaching powders, but really the process is extremely simple, and anyone with a little practice can test a sample in fifteen minutes; and as it will only be required to be done about once a fortnight, the time will be well spent. Having satisfied ourselves that our chemic is of good quality, it will be found that if, say, the contents of a 5 cwt. cask be well agitated in a stone cistern with 600 gallons of water, we shall have, after settling a few hours, about 600 gallons of good clear liquid chemic of about 10° Tw., and 1 gallon of this mixed with 20 gallons of water will be found quite strong enough for most purposes. Whether chemic at $\frac{1}{2}$° Tw. will be strong enough will depend much upon the purity of the water with which the goods are bleached; sometimes (especially in summer time) the water is so bad that it will destroy much of the chemic (even as much as 1° or 2° Tw.); in that case, of course, much stronger chemic liquor will have to be used. But in any case, no more chemic must be used than is really necessary to get a moderate white if the goods are to be printed and steamed, for an excess of chemic will form oxycellulose, and that would cause a tendering of the goods in the steaming process.

All goods do not receive the same treatment in the bleaching pro-

cess, but the following is the course of operations for three kinds of bleach :—

Madder Bleach.	*Market Bleach.*	*Market Bleach for goods with headings.*
Wash.	Lime boil—	Wash.
Lime Boil—	Wash.	Lime boil—
Wash.	Sour.	Wash.
Sour.	Wash.	Chemic.
Wash.	Soda ash boil—	Wash.
Ash and resin boil—	Wash.	Sour.
Wash.	Chemic.	Wash.
Soda ash boil—	Wash.	Ash boil—
Wash.	Sour.	Wash.
Chemic.	Wash.	Chemic.
Sour.	Soda ash boil—	Wash.
Wash.	Wash.	Sour.
Dry.	Chemic.	Wash.
	Wash.	Dry.
	Sour.	
	Wash.	
	Dry.	

Scouring for Goods to be Dyed Dark Shades.

Lime boil—	Soda ash boil—
Wash.	Wash.
Sour.	Dry.
Wash.	

NEW BLEACHING PROCESSES.

Many processes have been recommended in the last few years, and many patents have been taken out; but so far very few have been found of real utility. As a bleaching agent nothing, up to the present time, can displace bleaching powder or the hypochlorites generally. For special purposes it may be advisable to employ another hypochlorite, such as soda or magnesia, instead of the lime salt; but in those cases it is the hypochlorous acid which is being utilised, and, therefore, there is no novelty in the chemical reaction. In fact, some new products advertised with so much flourish as new bleaching agents, are simply one or other of the hypochlorites.

In the chemical bleaching process we may say there is really no novelty, the apparent novelties being simply modifications in the way of employment. But it is different with the mechanical arrangements; these have been, and are constantly being, improved, and progress in bleaching must be looked for principally in the improvement of machinery. Among the most noteworthy novelties in the bleaching processes for cotton is the

MATHER-THOMPSON PROCESS.

This is divided into two distinct operations—the scouring or cleansing, and the bleaching proper.

Scouring.—The pieces are stitched end to end in the ordinary way, so as to form a long rope, which can be worked in a continuous length and then treated with the hot solution of caustic soda, which has been employed in the former operation of scouring in the steamer kier. It is then washed and brought into waggon cages, there folded by machinery, and the cages are pushed into the

Steamer Kier.—This consists of a horizontal boiler or cylinder, one end of which can be entirely closed by means of a stout wrought-iron door, which can be lifted up and lowered by hydraulic arrangement. A centrifugal pump is connected with the top of the apparatus, which, by means of an inverted T-pipe fixed at the top of the steamer, and corresponding with the middle of each cage, allows a constant flow of the caustic lye on the cloth, through an arrangement of sprinklers, keeping the material constantly wet with the alkaline solution, and thus preventing decomposition. The caustic soda lye used in this operation is made up to 2° to 4° Tw., and will contain about 0·5 to 1 per cent. NaOH; the pressure employed is 4 lbs. to the square inch, and the duration five hours.

After steaming, the liquor is run off into the cistern below, and the kier is almost filled with hot water, which is kept in circulation by means of a pump, and thus washes the material. The water is then run off, the door opened, the cages removed, and the cloth rinsed with cold water, the scouring being complete.

The cages are constructed of galvanised iron lattice work, and are provided with a perforated column in the middle, by means of which the liquor can penetrate all through the cloth. Two cages will go into the steamer kier, and two tons of cloth can be treated at the same time.

The steamer kier can be and is largely used in connection with the ordinary bleaching process; in fact, with a little modification, it can be employed as a boiling kier, the circulation being effected by means of a pump, and lime can be used for scouring in the ordinary way.

The bleaching is effected in a series of troughs, in about the following order:—

1. Rinsing with hot water.
2. First chemic bath.
3. Passage through carbonic acid chamber.
4. Washing.
5. Scalding with soda ash.
6. Washing.
7. Second chemic bath.
8. Carbonic acid.
9. Wash.
10. Sour with hydrochloric acid.
11. Wash well and finish.

The cloth passes through the machine at the rate of 60 yards per minute. The novelty of this process is the employment of carbonic acid, which decomposes the hypochlorite of lime, forming free hypochlorous acid, and effects the bleaching; but carbonate of lime is precipitated on the fibre, which must be afterwards removed by the bath of hydrochloric acid. A very quick bleach is effected by the process, as cloth only takes about ten or twelve hours in all to go through the different operations, and a saving is effected in the amount of water used; a matter of grave consideration with bleachers who do not enjoy an unlimited supply of water.

The cloth, moreover, is not punished so much as in the old process; but it must be said that, although a good market bleach can be obtained by this process, the result is not quite so satisfactory for a madder bleach.

CHAPTER II.—PRINTING.

Hand-block Printing.—The actual printing—that is, the application of the colours to the tissue—is a purely mechanical process. Formerly, this operation was entirely performed by hand. The design, or rather portions of it, was applied by means of blocks. These are pieces of some hard, fine-grained wood, such as pear or sycamore, about 9 to 10 inches long by 5 broad and from 2 to 3 inches in thickness, fitted at the back with a stout handle. Upon the face of the block the design is carved much in the same manner as a wood engraving. Sometimes the pattern is formed by slips of copper—*i.e.*, flattened copper wire—inserted along its outlines, which are first traced upon the wood. The copper slips are carefully bent to the required shape, and are then forced into the positions they are to occupy by gentle hammering. The upper edges, where the copper stands above the wood, are levelled with the file, so as to form one even surface, and polished. The intervals between these slips are filled up within the boundaries of the design with pieces of thin felt.

In hand-block printing the piece to be operated on is spread out evenly upon the printing table—a strong structure, fixed so as not to rock or shake. It is generally about a yard high, 2 yards long, and 3 feet wide. Its top, upon which the piece rests, is a smooth, level slab of flagstone, from 4 to 5 inches in thickness, and it is covered with blanketing, stretched tightly across, and secured at the sides by hooks. At one end of the table is a roller, supported by brackets, and on it the piece to be printed is coiled, so that it may be drawn over the table as wanted.

Close to the printer stands a so-called colour tub. A wooden drum, like the woodwork of a sieve, is covered with a waterproof tissue, over which is stretched a fine woollen cloth, upon which the colour is spread. This drum is placed so as to float on a tubful of old paste.

The printer begins operations by unrolling a part of the piece from the roller above mentioned, and laying it smoothly over the top of the table. The selvage of the cloth is kept towards him, and runs at about an inch from the edge of the table. He observes how much of the piece will be covered by the block, and marks this by a line with a tracing-point. Meantime a boy, known as the tearer (probably *tireur*), spreads out the colour evenly with a brush on the drum-head. The printer then applies the face of his block to the drum-head twice, in different directions, so that it may be sure to be evenly supplied with

colour all over. He then lays it carefully upon the cloth and strikes it on the back with a hammer, or presses heavily upon it, so as to force the colour into the cloth. In the meantime the tearer brushes the colour up, so that it may always present an even surface. The printer lifts up his block, charges it afresh with colour, and re-applies it to the piece. Here there is need of great accuracy in working. If he brings his block too close to the spot where he placed it before, the impressions will, to some extent, overlap. If it is not brought close enough, a narrow interval will remain unprinted. If the sides of the block are not kept perfectly parallel with the edge of the piece, the design will necessarily become distorted. Accuracy in these points is secured by means of pin points fixed in the four corners of the block, so that each application may be made precisely where the former one left off. Judgment is also needed as to the quantity of colour taken up by the block at each application. If this is insufficient, the design may be too faint, and is said not to be "furnished." If too much colour is taken, smearing and spreading are the consequence. Hence, a block-printer requires no little experience before he can work both well and with reasonable despatch. When the length of cloth which has been drawn out and laid upon the table is thus printed, more is uncoiled, and the first portion is passed over one of a series of rollers fixed overhead, so that it may dry without being in the way or in danger of being smeared. The printer thus goes on until the entire roll is finished. The great drawback to this method of printing is the expenditure of time and labour involved. Take the case of a piece of calico of the ordinary length of 28 yards by 2 feet 6 inches—to print it over with the block of the size above mentioned will require 672 carefully managed applications. If there are four or five colours (nothing at all uncommon), the number of distinct applications will be respectively 2,688 and 3,360. Each block serves only for such parts of a design as are in one and the same colour. If we suppose, then, the colours in a design to be red, brown, yellow, and green, after the reds, *e.g.*, are all printed, the piece must be allowed to dry till there is no further danger of smearing, and a block with one of the other colours is then applied over the whole surface, in the same manner as before. Thus, in a many-coloured design, time and labour become very serious items.

For the generality of work blocking has, therefore, been laid aside in place of cylinder printing, of which we shall speak below. The block still retains a considerable importance in particular styles of work. Thus, in many cases, after a piece has been printed with mordants or resists, and dyed in the madder or indigo styles, further colours have to be superadded, in order to complete the design. These are then blocked in by hand, in the manner described above. As, however, this way of working necessarily involves additional expense, it becomes the object of printers to discover such ways of producing colours as will allow the entire design to be completed at once.

Flat-press Work.—The first step towards a method of printing more rapid than block-work was the use of flat plates, applied by means of a press very similar to that used in copper-plate printing. This kind of work, known as the "flat-press," was in vogue for some time at Mitcham. The designs thus printed show great neatness and correctness in outline and shading, and were mostly executed in one colour only. They were, in fact, engravings executed upon calico instead of paper.

Perrotine-machine Printing.—A very important step was the invention of the perrotine. This may be best characterised as a machine for performing block-printing without manual labour. It wields three blocks, much larger than those used in hand-printing, their length being equal to the width of the piece, and their width from 2 to 5 inches. They are engraved in the same manner as the hand-blocks. As each machine works three of these blocks, it executes in one operation designs in three colours. The machinery employed is of such a character that no description would render its working intelligible; it may suffice to say that the blocks are pressed against the cloth by certain springs, which represent the action of the block-printer's hand. One of these machines does an amount of work which would require, if done by hand, twenty printers, each with his attendant tearer, and is managed by a single workman, assisted by two children.

The perrotine has been but little used in England, but has been very generally adopted in Alsace and in Belgium.

Cylinder-machine Printing.—By far the larger part of tissue-printing is now executed with the cylinder machine, a Scotch invention due to a certain Mr. Bell (1785), and first used on the large scale by Livesey, Hargreaves & Co., of the Mossly Works, near Preston, Lancashire. Since then it has undergone many improvements, and has been adapted for applying at once as many as twenty distinct colours.

The printing machine consists of a large iron bowl or drum, against which are pressed the engraved copper cylinders; the colour is supplied to the engraved cylinders by wooden rollers covered with cloth, or sometimes by cylindrical brushes called "furnishers." The furnishers revolve in the colour, which is contained in long troughs called "colour boxes." But as the furnishers supply the whole surface of the engraved cylinders with colour, as well as the engraved parts, the surface colour has to be scraped off again, and this is done by means of a steel blade, known as the "colour doctor." The cloth to be printed passes partway round the bowl of the machine and between the engraved rollers and the bowl. It is whilst passing between the rollers and the bowl (or through the "nip," as it is called) that the cloth receives the colour, and in order that the cloth may be well pressed into the engraving so that it may take out all the colour, the iron-pressure bowl must be well lapped with some elastic material.

The lapping used for the bowl of the machine is a strong material made of a linen warp and woollen weft, about 10 or 12 thicknesses being carefully wound on the bowl, avoiding any creases or any unevenness, as the quality of the work done depends very much upon the evenness of the nip. Between the piece of cloth which is to be printed and the lapping of the bowl an endless web or blanket is interposed; this is a thick strong cloth generally made of pure wool; it should be of equal thickness throughout, as well as of uniform texture and elasticity. As the blanket has to be dried and cooled every time it goes round, it must of necessity be of a considerable length (40 to 50 yards), the ends must be very carefully sewn together, in such a manner as to leave no ridge, as any such ridge, crease, or any other unevenness would show in the print. The use of the blanket is to help the lapping in producing a good impression by virtue of its elasticity, to preserve the lapping and to protect it from damage and dirt. Of course, the blanket itself becomes dirty or worn, so much so that it must be replaced; but a good one will print 10,000 pieces before it becomes useless. Very often unbleached pieces of cloth (called back greys) are used for the purpose of keeping the blanket from getting dirty too soon; in this case the "back greys" are run between the blanket and the pieces which are being printed. Sometimes cotton cloth coated with indiarubber (called mackintoshes) are used instead of woollen blankets, and for some kinds of work the mackintosh is preferred. One advantage of the mackintosh is that, being water-proof, after every passage through the machine, it can be washed.

In order to remove any loose threads or filaments the so-called "lint doctor" is used, working on the opposite side of the engraved roller to which the colour doctor is applied. The doctors are generally made of well-tempered steel, and it is a very important part of the printer's business to so get up, by means of a file and oil-stone, the doctor's edge in such a way that it may effectually remove the surplus colour without doing injury to the engraved copper roller. Some colours (though they are becoming fewer every year) have a very injurious solvent or corrosive action upon the doctor's edge, which causes bad or streaky work. To remedy this, composition doctors of various kinds are used; but a good steel doctor is nearly always preferred whenever it can be applied; hence electro-plated steel doctors have come into use. The blade of the doctor is held in what are called shears—that is, it is clamped between two pieces of metal by means of pinching screws. The exact angle at which the doctor must press against the copper roller can only be determined by experience; but, as a rule, the colour doctor is set sharper or more horizontal than the lint doctor; for as the roller runs from the edge of the colour doctor and towards the edge of the lint doctor, the latter must not be set too keen or it would be liable to catch in the engraving, and so spoil the

roller. All colour or clearing doctors have a to-and-fro longitudinal motion called "traverse." This traverse motion is generally worked from the centre bowl by various methods—by bevil wheels and cranks, by eccentrics, by sinuous cam and levers, &c. The object of this traverse motion is to enable any particles of grit to pass from under the surface of the cleaner by the engraving of the roller, and to keep the edge of the cleaner evenly worn and clear.

As each engraved roller prints only one colour, there will, of course, be as many engraved rollers as there are separate colours in the design. Each roller is forced tight upon a solid axis called a mandrel. The copper rollers are not solid, but cylindrical shells, from $\frac{1}{2}$ to $1\frac{1}{4}$ inches thick, and have projecting pieces on the inside extending all the length of the roller. A corresponding groove is cut in the body of the mandrel into which the projecting piece of the copper roller fits, an arrangement which causes it to revolve with the mandrel without slipping. The mandrel is considerably longer than the roller, and about 18 inches of each end is less in circumference than the body; this is for convenience of carrying the mandrel with the roller for the purpose of changing, also for fitting in the bearings in which it has to run, and for the purpose of attaching the box wheel by which it is driven.

The various revolving parts of the machine as the bowl, mandrels, &c., are supported by two massive cast-iron cheeks or frames; between these frames the central iron bowl is supported in bearings so as to be free to revolve. The printing rollers are placed round the lower circumference of the bowl, each being tight on its mandrel, which has bearings on each side in the cheeks of the machine. Each roller is pressed into contact with the central bowl by weighted levers or screws, and has a colour box, furnishing roller, and two doctors. All the printing rollers of a machine are driven from the central or star wheel, which is concentric with the bowl, and drives the box wheel on the end of each mandrel. On one end of each mandrel is a small wheel, which gears into a similar small wheel on the end of the furnishing roller, for the purpose of driving the colour furnisher; by this arrangement the furnisher is driven in the reverse direction to the printing roller. If it is required to drive the furnisher in the same direction, then a third small wheel is interposed between the other two. There are many other parts and details of the printing machine too numerous and complicated to be described here; in fact, a many-colour printing machine (such as that shown on the opposite plate) is a most imposing piece of mechanism, but the action in working is somewhat as follows:—

The mandrel and roller being driven revolve the furnisher, and colour is raised and squeezed into the engraving of the printing roller, from which, in passing beneath the cleaning doctor blade, the surplus is removed and returned to the colour box. The bowl (having

the elastic blanket and lapping upon it) presses the white cloth into the engraved parts of the printing rollers, thus imprinting the cloth with a colour from each of the engraved rollers; the cloth having received its colours passes on to the drying apparatus; in the meantime the printing rollers, continuing their revolutions, meet the second doctors or linters, which scrape and clean their surfaces, removing colour and lint; they are then brought into contact again with the furnishers and receive fresh colours, &c. This goes on continuously as long as the machine is driven, and at such a speed that so much as a yard per second or 60 yards per minute can be printed. The following diagrammatic section (Fig. 11) of the working parts of the machine will perhaps help the uninitiated :—

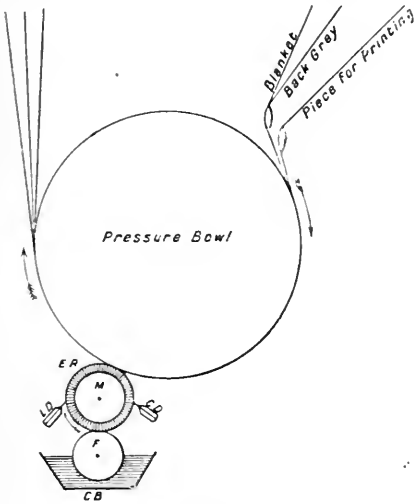

Fig. 11.

E R is the engraved roller.
F ,, furnisher.
C B ,, colour box.
L D ,, lint doctor.
C D ,, colour doctor.
M ,, mandrel.

The machine printer has many difficult duties to perform in order to turn out good work; the getting up of the doctor's edge has already been mentioned; then he has to get and keep the pattern rollers in register or fit, in order that the various colours shall fall exactly in the right places on the cloth so as to produce the design as required. Again he must carefully adjust the amount of pressure or "nip" so as to bring out the print and yet not press the colour too far through the cloth; he must see that the colour boxes are kept well supplied with colour, and also that the colours are kept as clean as possible. This latter is no easy matter for several reasons, the chief of which are—Firstly, because some colours have a corrosive solvent action upon the steel doctors or the copper rollers, so much so as to materially alter the shade of some colours; this is especially noticeable in alizarine pinks and oranges. Secondly, the first or back colours will work over into the later or front colours of a combination; on this account it is usual to work the light or "clean colours," as they are called, first, for if they were worked with the dark colours first, the light ones would soon become dirty and spoiled. Very often a starch roller is worked between printing rollers to prevent dark colours, coming before the starch roller, from getting into a pale colour working

after the starch roller. The starch roller is a plain roller (*i.e.*, without pattern) working in thin starch paste; it acts by squeezing the impressions of the first rollers into the cloth, at the same time taking some colour off the cloth so that the pale roller following cannot remove much from the cloth, and so its colour is kept clean. The lint doctors not only catch lint, but also clean the unengraved surface of the roller of colour which has been taken up by it from the cloth. After being printed the cloth must be immediately dried. This drying of the cloth after printing is of great importance: In some cases copper or tinned iron cylinders heated by steam are used for the purpose, but, as a rule, flat hollow cast-iron boxes called steam chests, over which the cloth passes without quite touching, are much better than cylinders, as the colours often stick to the drying cylinders, causing the goods to "mark off" or get dirty, besides which, unless great care is taken, some colours will be over-dried by being too long in contact with the hot cylinders.

Preparation.—After being bleached, and before printing, the cloth has to undergo a series of preparations:—1st. It is padded or prepared

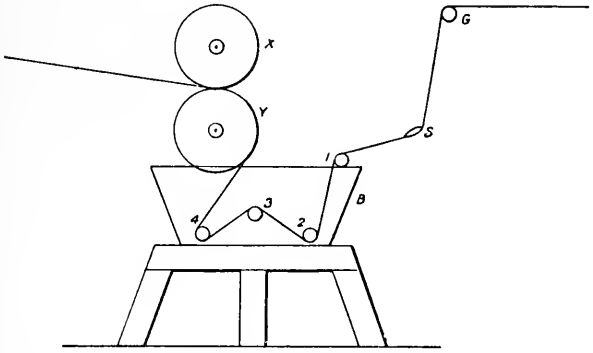

Fig. 12.—Preparing machine.

with oleine oil. This is done by passing the cloth in the open width through the preparing machine. The preparing liquor (1 of oleine oil, 50 per cent., and 15 of water) is contained in the box, B (Fig. 12). The dry pieces pass over guiding rollers, G, under the scrimp rail, S, into the liquor box; the pieces in passing under and over the rollers, 1, 2, 3, 4, become thoroughly saturated with the solution, after which they pass between the squeezing bowls, X and Y, which expel any excess of liquor. These squeezing bowls are made of wood, and lapped with a few thicknesses of cloth, and the degree of pressure is regulated by means of screws at the top of the machine. After being padded the goods are dried, sometimes in the hot flue, but generally on drying cylinders.

After being prepared, the ends of the pieces are marked with the order numbers and certain particulars which inform the workmen as

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to the precise treatment the goods must undergo. After being stamped they are sewn end to end by machines in batches of from ten to twenty pieces. After being sewn, each batch is taken to the shearing and winding-on machines, generally called a "canroy." Sometimes the shearing machine and canroy are two separate machines; but combined shearing and winding-on machines are now made. On entering the canroy the cloth first passes over "scrimp rails" (see Folding plate); these are brass bars having V-shaped grooves on their upper faces which throw out the edges of the cloth, thus keeping it at the full width. From these rails the cloth passes under a frame that depresses the face of the piece into contact with the circular cutters and revolving brushes. The cutting blades revolve in a direction opposite to that in which the cloth is passing, so that all the nap is cut off, and the lint is afterwards removed by the brushes. The cloth is wound on a "shell" which is carried by a movable "centre," and is then ready for printing.

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CHAPTER III.—MORDANTS.

Chemical Elements.—Before we can understand the properties, use, and mode of preparation of mordants, we must first make a brief study of the nature of the chemical elements. The chemical elements are those simple forms of matter of which all complex substances are composed. Thus chalk is composed of calcium, carbon, and oxygen; calcium, carbon, and oxygen are thus the elements of chalk, and chalk is said to be a compound because it is made up of these elements. Common salt is composed of the elements sodium and chlorine, and common salt is called a compound because it consists of these two elements. Calcium, carbon, chlorine, &c., are elements, and not compounds, because they are not made up of two or more things. The chemical elements which are of interest to the bleacher, dyer, and printer are about thirty in number. In the following table the names of these thirty elements are given in the first column; in the second column the signs or symbols which are assigned to them by the chemist; and in the third column the relative weights which these symbols stand for:—

Name of Element.	Symbol.	Symbol Weight.
Aluminium,	iv Al	27·4
Antimony,	v Sb	122
Arsenic,	v As	75
Barium,	ii Ba	137
Boron,	iii B	11
Bromine,	i Br	80
Cadmium,	ii Cd	112
Calcium,	ii Ca	40
Carbon,	iv C	12
Chlorine,	i Cl	35·5
Chromium,	iv Cr	52
Copper,	ii Cu	63
Fluorine,	i F	19
Hydrogen,	i H	1
Iodine,	i I	127
Iron,	iv Fe	56
Lead,	iv Pb	207
Magnesium,	ii Mg	24
Manganese,	iv Mn	55
Mercury,	ii Hg	200
Nitrogen,	iii N	14
Oxygen,	ii O	16
Phosphorus,	v P	31
Potassium,	i K	39
Silicon,	iv Si	28
Sodium,	i Na	23
Sulphur,	vi S	32
Tin,	iv Sn	118
Vanadium,	v V	51
Zinc,	ii Zn	65

Compounds.—Compound substances are represented by means of formulæ. The formula of a compound should contain the symbols of all the elements of which the compound is composed: thus, common salt is composed of the elements sodium and chlorine, its formula is, therefore, made up of the symbols Na and Cl. NaCl is the formula of common salt, and this formula tells us how much sodium and chlorine common salt contains—viz., 23 parts of sodium and 35·5 parts of chlorine, by weight, in every 58·5 parts of common salt. The salt called stannous chloride, or, as dyers generally call it, "tin salt" or "tin crystals," is composed of the elements tin and chlorine; the formula of this salt will be made up of the symbols Sn and Cl. Now we know that Sn stands for 118 parts of tin and Cl for 35·5 parts of chlorine, but as stannous chloride is known to contain 118 parts of tin combined with 71 parts (twice 35·5) of chlorine, the formula of this salt will contain only 1 Sn to 2 Cl, which could be written SnClCl or $SnCl_2$; the latter is the usual way of writing it. It will be noticed that each of the symbols for the thirty elements is marked on the left side with a Roman numeral; these numbers indicate what is called the combining power or valency of each of the elements: thus, oxygen, O, is marked with two dashes, whilst hydrogen, H, has only one dash; this indicates that one O is equal in value to two H, and when these elements combine to form water, they do so in the proportion of one O to two H, so that the formula of water is OH_2, or 16 parts of oxygen to 2 parts of hydrogen by weight.

Classification.—Substances may be divided into three classes, viz.:—1st, Basic or positive substances; 2nd, acid or negative substances; and 3rd, salts or neutral bodies. A base is a metal, or a combination of a metal with oxygen; an acid is a non-metal, or a combination of a non-metal with oxygen or hydrogen; a salt or neutral substance is formed when a basic or positive substance combines with a negative or acid substance. Thus, the neutral substance Glauber's salt or sulphate of soda, Na_2OSO_3, is made up of the positive or basic substance soda, Na_2O, and the negative or acid substance sulphuric anhydride, SO_3. The following is a list of the salts most interesting to the bleacher, dyer, and printer, showing their basic and acid constituents:—

Name of Salt.	Positive or Basic part.	Negative or Acid part.	Weight of Molecule.
Aluminium sulphate,	Al_2O_3	$(SO_3)_3(H_2O)_{18}$	667
Sodium ,,	Na_2O	SO_3	142
Calcium ,,	CaO	SO_3	136
Lead ,,	PbO	SO_3	303
Ferrous ,,	FeO	$SO_3(H_2O)_7$	278
Zinc ,,	ZnO	$SO_3(H_2O)_7$	287
Copper ,,	CuO	$SO_3(H_2O)_5$	249
Magnesium ,,	MgO	$SO_3(H_2O)_7$	246
Aluminium acetate,	Al_2O_3	$(C_4H_6O_3)_3$	409
Chromium ,,	Cr_2O_3	$(C_4H_6O_3)_3$	458
Ferrous ,,	FeO	$C_4H_6O_3$	174
Calcium ,,	CaO	$C_4H_6O_3$	158
Lead ,,	PbO	$C_4H_6O_3(H_2O)_3$	379
Stannous ,,	SnO	$C_4H_6O_3$	236
Stannic ,,	SnO_2	$(C_4H_6O_3)_2$	354
Calcium chloride,	Ca	Cl_2	111
Stannous ,,	Sn	$Cl_2(H_2O)_2$	225
Manganese ,,	Mn	$Cl_2(H_2O)_4$	198
Sodium bichromate,	Na_2O	$(CrO_3)_2$	262
Sodium chromate,	Na_2O	CrO_3	162
Lead ,,	PbO	CrO_3	323
Sodium phosphate,	$H(Na_2O)$	$PO_3(H_2O)_{12}$	358
,, silicate,	$(Na_2O)_2$	SiO_2	184
,, carbonate,	Na_2O	$CO_2(H_2O)_{10}$	286
,, chloride,	Na	Cl	58·5
,, stannate,	Na_2O	SnO_2	212
,, chlorate,	Na_2O	Cl_2O_5	213
Aluminium sulpho-cyanide,	Al_2	$(CNS)_6$	403
Stannic chloride,	Sn	Cl_4	260
Copper nitrate,	CuO	N_2O_5	187
Lead ,,	PbO	N_2O_5	331
Copper sulphide,	Cu	S	95
Barium sulpho-cyanide,	Ba	$(CNS)_2$	253
Sodium-hydrogen sulphite,	$NaHO$	SO_2	104
Potassium ferro-cyanide,	K_4	$Fe''(CN)_6(H_2O)_3$	422
,, ferri-cyanide,	K_3	$Fe'''(CN)_6$	329

Sometimes these salts combine with one another, and with water, to form very complex and crystalline salts; this is the case with aluminium sulphate and potassium sulphate, which crystallise together and with water to form common alum, the composition of which is indicated by the formula—

$$Al_2O_3(SO_3)_3K_2OSO_3(H_2O)_{24}.$$

From this formula we see that alum is made up of

103 parts of the base alumina.
94 ,, ,, potash.
320 ,, ,, acid sulphuric anhydride.
432 ,, water in

949 parts of alum by weight.

Mordants.—This complex salt, **alum,** was one of the first substances used as a mordant for fixing colouring matters; but it is only

its base alumina which is useful for this purpose; this base combines with the acid colouring matters to form insoluble salts. Alum would seem to be a rather expensive source of alumina, seeing that it only contains about 11 per cent. of that base. Anhydrous sulphate of alumina, $Al_2O_3(SO_3)_3$, is a cheaper source of alumina, as it contains about 30 per cent. of the base. The pure alumina itself cannot be used as a mordant, because it is not soluble in water; for, in order to get a substance to combine with cotton, we must first make a solution of it, in order that it may enter the pores of the fibre; the substance must then be rendered insoluble, so that it cannot get out of the fibre again. However, alum and sulphate of alumina are not the best substances to use for the purpose of supplying alumina to the cotton fibre; the acetate of alumina being a far better substance for this purpose, especially if we desire to print a pattern in alumina mordant, which is to be afterwards dyed up with one of the acid colouring matters.

The **acetate of alumina** or "red liquor," as it is called, is very largely used by dyers and calico-printers, and is generally prepared in one of the following ways:—

1st. By dissolving alumina in acetic acid.

2nd. By mixing together solutions of lime acetate and alumina sulphate.

3rd. By mixing lead acetate with alum or sulphate of alumina.

These three methods of preparing acetate of alumina can be represented by chemical equations as follows:—

1st method—$\underset{\text{Alumina.}}{Al_2O_3} + \underset{\text{Acetic Acid.}}{3H_2OC_4H_6O_3} = \underset{\text{Alumina Acetate.}}{Al_2O_3(C_4H_6O_3)_3} + \underset{\text{Water.}}{3H_2O}.$

2nd method—$\underset{\text{Lime Acetate.}}{3CaOC_4H_6O_3} + \underset{\text{Alumina Sulphate.}}{Al_2O_3(SO_3)_3} = \underset{\text{Alumina Acetate.}}{Al_2O_3(C_4H_6O_3)_3} + \underset{\text{Lime Sulphate.}}{3CaOSO_3}.$

By this method insoluble lime sulphate is formed; this is allowed to settle to the bottom, and is thrown away as it is of no use; the clear solution only being the "red liquor."

3rd method—$\underset{\text{Lead Acetate.}}{3PbOC_4H_6O_3(H_2O)_3} + \underset{\text{Alum.}}{Al_2O_3(SO_3)_3K_2OSO_3(H_2O)_{24}}$

$= \underset{\text{Alumina Acetate.}}{Al_2O_3(C_4H_6O_3)_3} + \underset{\text{Potash Sulphate.}}{K_2OSO_3} + \underset{\text{Lead Sulphate.}}{3PbOSO_3} + \underset{\text{Water.}}{(H_2O)_{33}}.$

This last method being more expensive is not so much used now as formerly.

We learn from the above equations the proportion in which the ingredients must be mixed together in order to produce red liquor; thus, from the first equation we see that 103 parts by weight of alumina require 360 parts by weight of pure acetic acid, or 1,200 parts by weight of the commercial acid containing about 30 per cent., in order to form 463 parts of alumina acetate.

By the 2nd equation we find that 474 parts of pure dry acetate of lime require 343 parts of anhydrous sulphate of alumina by weight,

to produce 409 parts of alumina acetate and 408 parts of sulphate of lime.

From the 3rd equation we find that 1,137 parts of crystallised acetate of lead require 949 parts of alum to produce 409 parts of alumina acetate, 174 parts of potash sulphate, 909 parts of lead sulphate and 594 parts of water by weight. The above examples illustrate the great value of chemical equations, as they not only show the way in which the chemicals act upon one another, but also the exact proportions by weight in which we must mix them in order to produce any substance we may require. The advantages of acetate of alumina over most other alumina salts as a mordant are—1st, its comparatively low price; 2nd, its extreme solubility, as owing to this, cloth may easily be charged with a large quantity of the mordant; 3rd, its unstability, by virtue of which the acetic acid is readily given off, leaving the insoluble alumina upon the cloth in a condition in which it will readily combine with the acid colouring matters.

Ferrous acetate or "black liquor" is a similar compound to "red liquor," and is used in the same way and for the same purpose—*i.e.*, as a mordant for the acid colouring matters; it is prepared by the following methods, which are very similar to those by which "red liquor" is prepared:—

1st. By dissolving iron or the hydrate of iron or the carbonate of iron in acetic acid, generally the crude pyroligneous acid is used—

Iron.		Acetic Acid.		Ferrous Acetate.		Hydrogen.
Fe	+	$H_2OC_4H_6O_3$	=	$FeOC_4H_6O_3$	+	H_2.

Ferrous Hydrate.		Acetic Acid.		Ferrous Acetate.		Water.
$FeOH_2O$	+	$H_2OC_4H_6O_3$	=	$FeOC_4H_6O_3$	+	$2H_2O$.

Carbonate of Iron.		Acetic Acid.		Ferrous Acetate.		Water.		Carbonic Anhydride.
$FeOCO_2$	+	$H_2OC_4H_6O_3$	=	$FeOC_4H_6O_3$	+	H_2O	+	CO_2.

2nd. By mixing lime acetate and ferrous sulphate (copperas)—

Lime Acetate.		Ferrous Sulphate.		Ferrous Acetate.		Lime Sulphate.		Water.
$CaOC_4H_6O_3$	+	$FeOSO_3(H_2O)_7$	=	$FeOC_4H_6O_3$	+	$CaOSO_3$	+	$7H_2O$.

3rd. By mixing lead acetate and ferrous sulphate—

Lead Acetate.		Ferrous Sulphate.		Ferrous Acetate.		Lead Sulphate.		Water.
$PbOC_4H_6O_3$	+	$FeOSO_3(H_2O)_7$	=	$FeOC_4H_6O_3$	+	$PbOSO_3$	+	$7H_2O$.

The quantities by weight of each of the substances to be taken can be easily calculated from the above equations.

CHAPTER IV.—STYLES OF CALICO-PRINTING.

The two mordants, red liquor and black liquor, are very largely used by calico-printers in what is called

THE DYED, OR MADDER STYLE.

This is one of the oldest and most important of the various styles of calico-printing. In this style the thickened mordants are first printed on, then dried, aged, dunged, and dyed with alizarine, or other acid colouring matters.

The mordants have first to be made into what are technically called "colours" before they can be printed; that is, they have to be made into a kind of paste by means of some thickening matter, as starch, gum, &c. These colours are not necessarily coloured substances, though they do usually contain some kind of colouring, but this is only for the purpose of *sightening*, so that the printer may be able to see his work on the cloth; this sightening is washed out of the cloth after it is printed during the process of dunging (see patterns 1 to 1E). The following are recipes for some of the colours generally used in the "dyed styles":—

Colour No. 1.—8° Tw. Red.

Water,	8 gallons.
Magenta,	½ oz.
Red liquor, 16° Tw.,	8 gallons.
Wheat starch,	16 to 32 lbs.
Colour oil,	½ gallon.
Boil, and stir till cool, then add	
Tin crystals,	2 lbs.

This colour, when dyed up with alizarine, gives a medium red—hence the term red liquor; but the same colour if dyed up with quercitron bark would give a yellow; if dyed up with cœruline paste an olive green would be produced; and, again, if dyed up with alizarine blue paste a kind of indigo blue would be obtained. Therefore, the term "red liquor" must only be understood in its technical sense, as almost any kind of shade can be dyed upon this mordant; the shade really depends upon the colouring matter used, the mordant only regulates the depth of the shade. If we want to produce a darker shade we must use a stronger mordant; if we want a lighter shade a weaker mordant must be used.

The following would give a very full red, yellow, olive, &c.:—

No. 2.—12° Tw. Red.

Water,	4 gallons.
Magenta,	¾ oz.
Red liquor, 16° Tw.,	12 gallons.
Wheat starch,	16 to 32 lbs.
Colour oil,	½ gallon.
Boil, cool, and add	
Tin crystals,	3 lbs.

For pinks, light yellows, olives, &c., the following may be used :—

No. 3.—1° Tw. Red.

Water,	15 gallons.
Magenta,	¼ oz.
Red liquor, 16° Tw.,	1 gallon.
Wheat starch,	16 to 32 lbs.
Colour oil,	½ gallon.
Boil, and cool, then add	
Tin crystals,	½ lb.

It will be observed that in these recipes the amount of starch to be used as thickener varies considerably—from 1 to 2 lbs. per gallon of colour; the reason of this is that the consistency of colour required depends upon the pattern, the depth of the engraving, &c.; fine and intricate patterns, on newly engraved rollers, will require much thicker colours than blotchy patterns, especially if the engraving has got worn down by much use; but the exact thickness a colour should be can only be determined after considerable experience. The magenta is only put into these colours as "sightening" for the printer, so that he may see if he is printing them on the right place on the cloth.

The tin crystals are for the purpose of preventing the fixation of any iron upon the cloth, as very small quantities of iron impairs these colours, especially pinks and other light and bright colours. Other thickeners than wheat starch are often used, such as British gum, gum Senegal, flour, &c.; these, however, will be treated of in the chapter on thickeners, p. 69.

It is not always necessary to boil colours of the exact strength required for printing; it is found more convenient to make a strong colour, which is referred to as a "standard" or "stand," and this standard is then reduced with paste to the required strength. A strong colour thus reduced is said to be made so many dark, or so many light, written Dk. and Lt.; thus we could make No. 1 colour from No. 2 colour, by taking two measures of No. 2 colour and one measure of starch paste; the No. 2 colour in this case would be considered the "stand" and the starch paste the "reduction." The "stand" in this case is said to have been made 2 Dk.—*i.e.*, 2 parts of the Dk. or strong colour and 1 part of reduction. In a similar manner a 4° Tw. red colour could be made off the same "stand" by taking one measure of the "stand"—12° Tw. red—and two measures of reduction; in this

case the stand is said to have been reduced 2 Lt., a 3° Tw. is 3 Lt. off a 12° Tw. red, &c. This system of speaking of one colour as so many Dk. or Lt. off another is found to be very convenient in practice in the colour shop.

The following is a good and cheap starch thickening for reducing colours of the dyed or madder styles :—

Starch Thickening.

Water,	16 gallons.
Wheat starch,	20 lbs.
Acetic acid, 30 per cent.,	½ gallon.
Colour oil,	½ ,,

Boil, and stir till cool.

Acetate of iron or "black liquor" is now very seldom used for dyeing up a black, as aniline black gives much better results. Notwithstanding this, acetate of iron is still very much used for the production of purples, lilacs, &c.

No. 4.—6° Tw. Purple (Stand).

Acetate of iron, 24° Tw.,	4 gallons.
Water,	10 ,,
Purple fixing liquor,	1 gallon.
Wheat starch,	12 lbs.
British gum,	32 ,,
Colour oil,	½ gallon.

Boil, and stir till cool.

Purple Fixing Liquor.

Water,	1 gallon.
Soda crystals,	12 lbs.
Arsenious acid,	10 ,,

Boil until solution is completed, dissolve, then add

Acetic acid,	20 gallons.

Let the sediment settle, and to the clear liquid add

Hydrochloric acid,	1 quart.

Lilacs are simply reduced purple.

By mixing acetate of alumina and acetate of iron in the same colour, a great variety of shades can be produced, varying according to the proportion of either; when dyed in alizarine they produce shades generally known under the name of chocolates; but by dyeing up with other acid colouring matters almost any flat or dull shade of colour can be produced. The following are a few recipes for the so-called chocolate "colours" :—

No. 5.—8/3 Chocolate.

Red liquor,	8 gallons.
Iron liquor,	2 ,,
Water,	6 ,,
Logwood liquor,	½ gallon.
Colour oil,	½ ,,
Wheat starch,	20 lbs.

Boil, and stir till cool.

No. 6.—8/6 Chocolate.

Red liquor,	8 gallons.
Iron liquor,	4 ,,
Water,	4 ,,
Logwood liquor,	½ gallon.
Colour oil,	½ ,,
Wheat starch,	16 lbs.
British gum,	16 ,,

Boil, and stir till cool, &c.

The following aniline black colours are those generally used for the madder style, as they can be developed without steaming, and are not injured in the dunging and dye-becks :—

No. 7.—Aniline Black.

Water,	16 gallons.
Wheat starch,	24 lbs.
Chlorate of soda,	8 ,,
,, potash,	4 ,,

Boil, and add

Aniline salts,	18 ,,
Aniline oil,	½ lb.

And when cold, add

Sulphide of copper,	½ gallon.

Sulphide of Copper.

(A)	Sulphate of copper,	15 lbs. Dissolve in
	Water,	10 gallons.
(B)	Flowers of sulphur,	3 lbs.
	Caustic liquor, 70° Tw.,	1 gallon.

Stir occasionally until all is dissolved.

Add (B) to (A) and wash several times by decantation, and drain on the filter to 2 gallons.

Instead of the sulphide of copper, some prefer a solution of vanadium salt ; a very small quantity of this vanadium compound is found to be effective—say 160 grains of bi-vanadiate of ammonia dissolved in 1 quart of water—for the above quantity of colour. Care must be taken in the preparation of these aniline black colours, as if they are made too long before they are wanted, or allowed to become warm, they act upon the doctor and work badly.

After the mordants have been printed the cloth is dried, care being taken not to overdry on the hot tins, as this would act injuriously on the mordants. Next follows the ageing process, the object of which is to decompose the acetates, so that the acetic acid is driven off, leaving the insoluble bases on the fibre. For this purpose large rooms called ageing rooms were formerly used, in which the goods were hung up for several days, and the temperature kept up to 80° F. on the dry bulb, the wet bulb showing about 4° F. lower. In these ageing rooms most of the acetic acid is given off from the mordants, and at the same

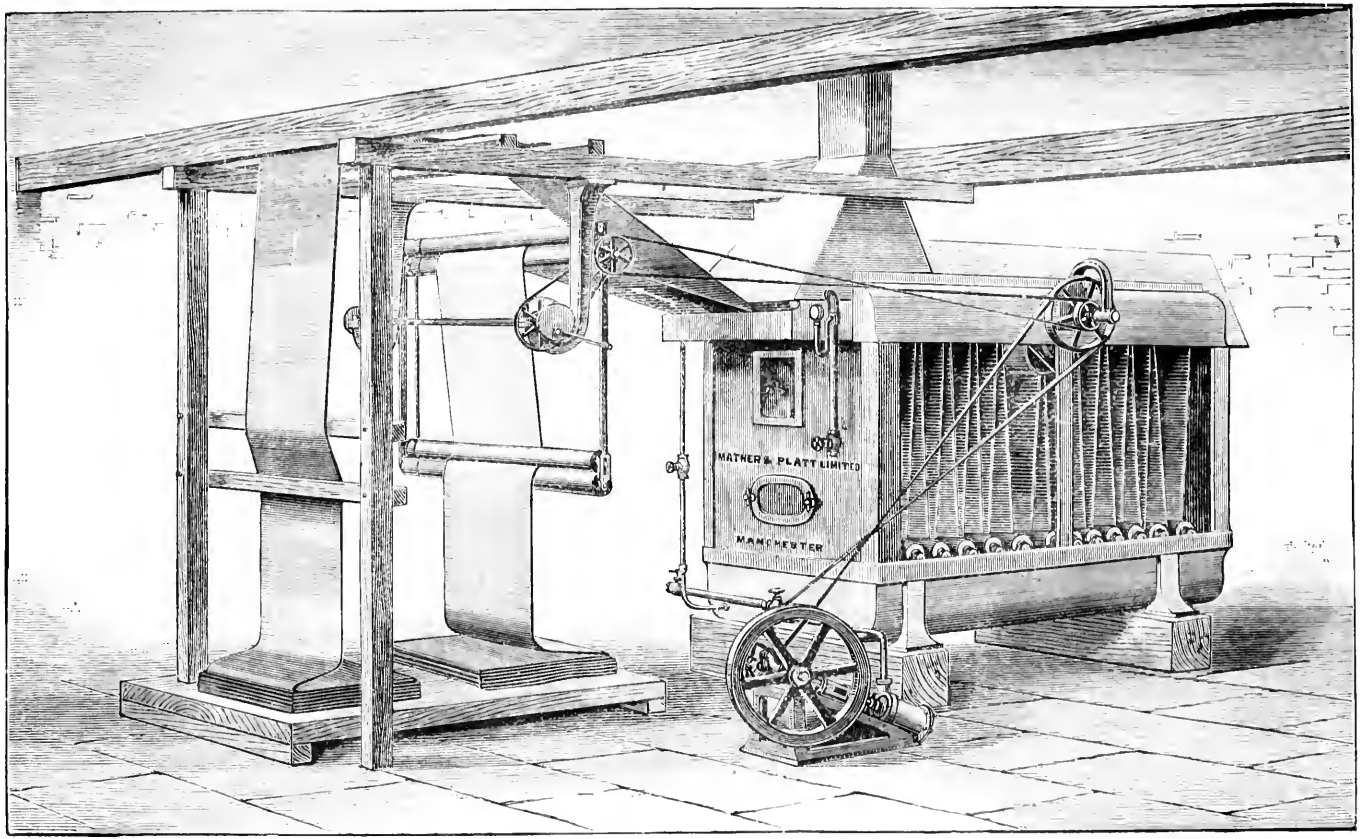


Fig. 13.—Continuous steam ageing machine.

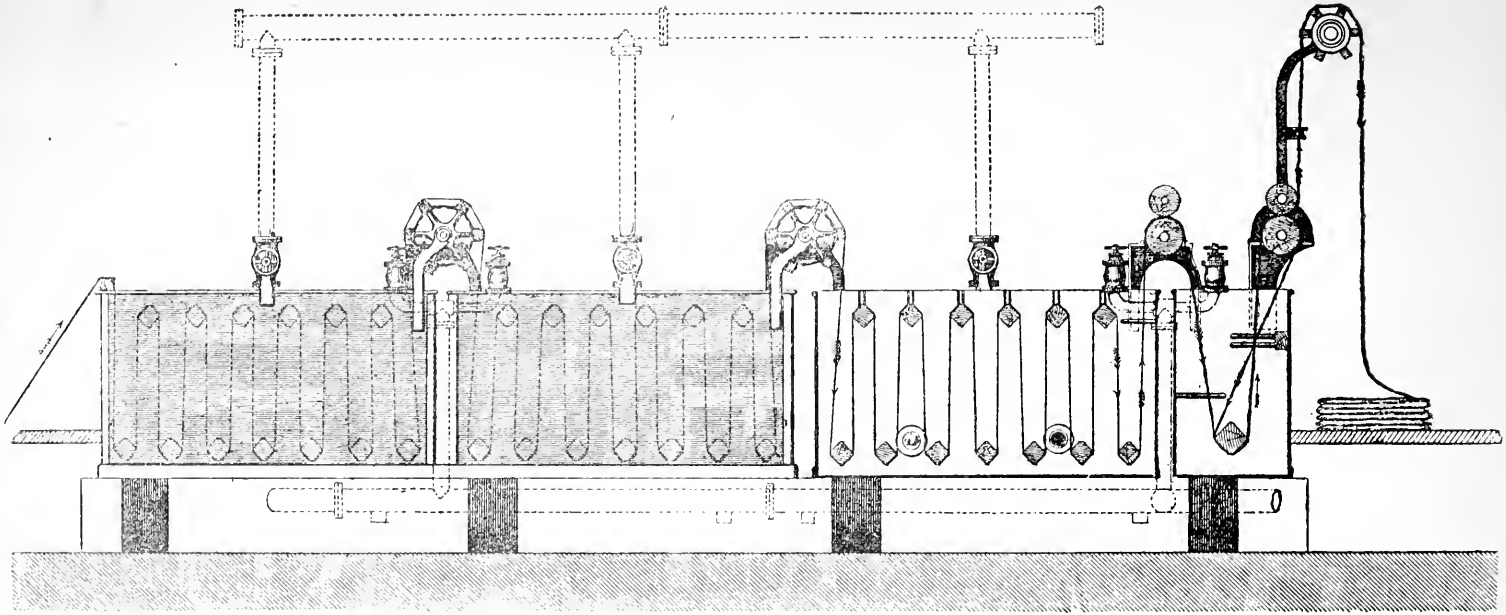


Fig. 14.—Continuous system of first dunging or dolly.

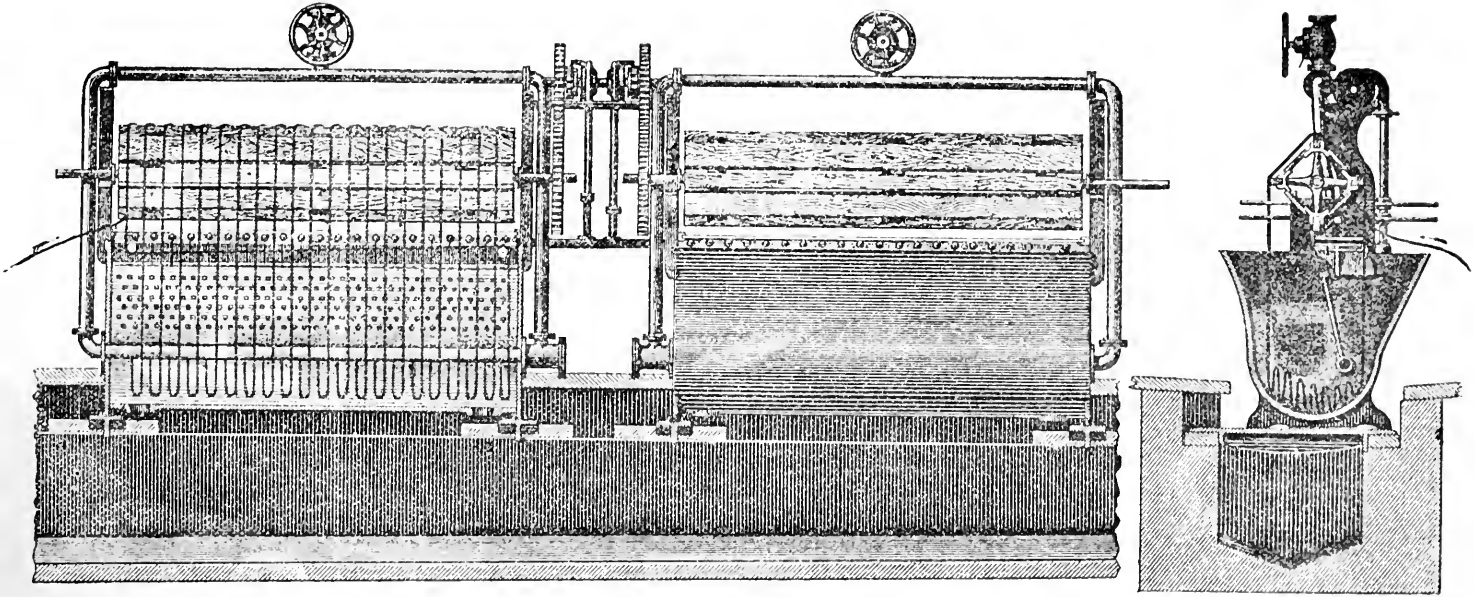


Fig. 15.—Dye-beck, arranged either to dye on the endless system or in separate pieces between each peg.

time the aniline black is developed. Many works now employ steam ageing machines (Fig. 13), through which the goods are run, the cloth being then folded up in loose bundles and left for twenty-four hours. The decomposition of the mordants, which was started by the action of the steam in the ageing machine, will slowly go on whilst the cloth lies in the bundles if kept in a warm room. This latter method is a quicker and more economical one, but it is not so good nor so safe as the old method, for unless much care be taken, the aniline black will be developed too quickly and the cloth will be tendered.

The ageing does not effect a complete precipitation of a suitable mordant on the fibre, and must be followed by the so-called

Dunging or Fixing Process.—This operation consists simply in passing the cloth in a continuous manner through the dunging apparatus or cisterns (Fig. 14) containing the dunging liquors.

1st Bath.—	Water, ...	512 gallons, 75° C.
	Phosphate of soda, . . .	16 lbs.
	Ammonia liquor, . . .	8 ,,
	Ground chalk, ...	16 ,,
2nd Bath.—	Water, ...	512 gallons.
	Phosphate of soda, . . .	8 lbs.
	Cow dung, ...	160 ,,
	Ground chalk, ...	16 ,,

The cloth will take about one minute to run through each of the above baths, and is then worked for thirty minutes at 75° C. in the dunging beck containing—

Water, ...	500 gallons.
Cow dung, ...	50 lbs.
Ground chalk, ...	5 ,,

After a thorough washing the cloth is now ready for

The Dyeing.—For the madder style this is usually done in the spiral dye-beck (Fig. 15); the cloth being in the rope, is drawn by a winch, or else by draw-bowls, in an endless manner through the beck; peg rails are used to keep the cloth in its proper place. As already explained, the colouring matter to be used in the dyeing will depend upon the shade required. Another thing to be noticed is that the amount of colouring matter to be used will depend upon the kind of pattern printed—some patterns requiring ten times more colouring matter than others; then, again, it must be observed that in this style we have not only to dye up the pattern, but also to keep the white parts as clean as possible, and for this purpose other materials besides colouring matters are added to the dye-beck. It will be readily seen from these facts that it is impossible to state the exact amount of materials to be used without seeing the pattern, but the dyer can easily do so by "springing a fent." The following may be taken as the corresponding proportion of the different substances to be used in the dye-bath, say for 1,000 yards of 36-inch cloth in a medium pattern printed in red and pink :—

500 gallons water.
12 lbs. alizarine, 20 per cent.
1 lb. tannic acid.
5 lbs. glue size.
1 lb. ground chalk.
3 lbs. alizarine oil.

The dyeing is started at 25° C., raised in one hour to 75° C., and continued at this temperature for another fifteen minutes. The above materials are not all indispensable for the dye-bath, as good reds and pinks have been dyed with nothing but pure alizarine; much depends upon the water obtainable, and something, no doubt, upon the whims

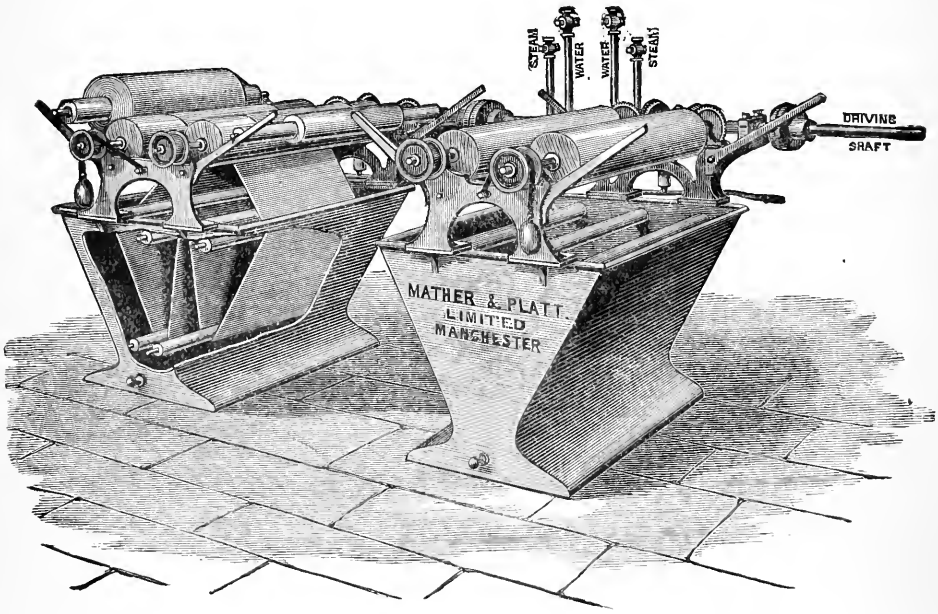


Fig. 16.—Lancashire jigger, for dyeing cloth in the open width.

and fancies of the dyer. After dyeing, the cloth is well washed in cold water, and afterwards dried. It is next prepared with padding liquor. In regard to this padding liquor, it is the same with this as with almost everything used by bleachers, dyers, and printers; each one has his own fancies, and each one thinks he is in possession of something better than his *confrères*. However, it is probable that all that is required is a solution of oleine oil (about 1 part in 20); some dyers add to this ammonia, others add soap, tin crystals, milk, and many other things, but if anything besides oleine is required, perhaps a small quantity of stannate of soda is as good an addition as can be made; at all events, after padding, the cloth must be dried and steamed for one hour, after which it is well soaped, washed, and dried;

though, if the whites are not good, they may require a weak chemicking before the final drying.

What has been said about reds and pinks will apply equally to chocolates, browns, drabs, yellows, olives, and all other dyed shades in this style. In connection with the dyed style we have the

RESIST PADDED STYLE.—In the resist style the cloth is printed with a colour which will prevent the pad colour from being fixed on the part where the resist or reserve has been applied. These resist colours, intended to resist the mordants of alumina and iron, are mostly composed of citrate of soda, which is prepared by mixing citric acid or lime-juice with caustic soda. This resist, where applied to the cloth, prevents the fixation of the mordants on the fibre, and, therefore, when the cloth is afterwards dunged and dyed, the reserved parts remain white (see patterns 8 to 8F); in this way reversed patterns are produced. Thus, suppose a roller is engraved so as to print spots in, say, a red mordant, this, by dyeing up with alizarine, would give red spots on a white ground; if, now, we print with the same roller a resist colour, afterwards pad this over with a red mordant, and then dye up with alizarine, we should have a pattern in white spots on a red ground. The following are some of the reserve colours in use :—

No. 8.—Resist for Mordants.

Lime-juice, 50° Tw.,	6 gallons.	
Caustic soda ley, 70° Tw.,	4 ,,	
Water,	4 ,,	
Magenta,	½ oz.	
British gum,	64 lbs.	Boil, &c.

Or, citric acid may be used in place of lime-juice.

No. 9.—Resist for Mordants.

Citric acid crystals,	24 lbs.	
Water,	11 gallons.	
Caustic soda,	13 lbs.	
Magenta,	½ oz.	
British gum,	64 lbs.	Boil, &c.

Instead of a pad roller, sometimes a roller engraved with a fine pattern called a "cover" is used for printing over a pattern in resist. The following is a red resist for a purple cover :—

No. 10.—Resist Red.

Water,	12 gallons.
Red liquor, 16° Tw.,	4 ,,
Wheat starch,	16 to 32 lbs.
Boil, stir till cool, then add	
Tin crystals,	12 lbs.

Where this red resist is printed the tin crystals will prevent the iron of the purple cover from being fixed, so that when the pattern is dyed up with alizarine only a red will be produced where the two

colours are superposed, but a purple would be produced where the cover does not fall on the resist.

No. 11.—Resist for Aniline Black (see pattern No. 11).

Acetate of lime, 20° Tw.,	14 gallons.	
British gum,	64 lbs.	Boil, &c.

With the following resists a great variety of shades may be dyed up after the black has been developed :—

No. 12.—Resist for Aniline Black.

Acetate of lime, 24° Tw.,	7 gallons.	
,, alumina, 16° Tw.,	7 ,,	
British gum,	64 lbs.	Boil, &c.

Resist for Aniline Black.

Acetate of lime, 24° Tw.,	7 gallons.	
,, alumina, 16° Tw.,	6 ,,	
,, iron,	1 gallon.	
British gum,	64 lbs.	Boil, &c.

No. 13.—Acetate of Lime 24° Tw.

(*a*) Acetic acid, 30 per cent.,	10 gallons.	
(*b*) Ground chalk,	24 lbs.	
Hot water,	6 gallons.	

Add (*b*) to (*a*), stirring well all the time.

All the above resists are strong colours, "stands," and may be reduced when required to resist weaker mordants; for this purpose British gum thickened at 5 lbs. per gallon may be used.

Another method of producing a reversed pattern is the

DISCHARGE STYLE.—In this style the cloth is first dyed (see Plain Dyes, pp. 114–124), then the pattern is printed with some colour, which, by further treatment, will discharge the dye from the cloth, leaving a white or some other shade differing from the ground. The following are the usual discharges for a Turkey red ground :—

No. 14.—White Discharge on Turkey Red.

Tartaric acid crystals,	84 lbs.	
British gum,	64 ,,	
Water,	14 gallons.	Boil, &c.

No. 14*a*.—Yellow Discharge on Turkey Red.

Tartaric acid,	64 lbs.	
Nitrate of lead,	64 ,,	
Water,	16 gallons.	
Wheat starch,	24 lbs.	Boil, &c.

No. 15.—Blue Discharge on Turkey Red.

a) Prussian blue pulp,	16 lbs.	
Oxalic acid,	16 ,,	
Water,	4 ,,	

Let this stand for twenty-four hours, stirring occasionally.

b) Water,	. . . . .	12 gallons.
Wheat starch,	. . . . .	20 lbs.
Tartaric acid,	. . . . .	48 ,,

Boil, and stir till cool, then add (*a*) and stir till cold.

Green discharges are made by mixing together the yellow and blue discharges to shade required.

No. 16.—Black Discharge for Turkey Red.

Logwood liquor, 4° Tw.,	. . . . .	10 gallons.
Yellow prussiate of potash,	. . . . .	8 lbs.
,, ,, soda,	. . . . .	8 ,,
Wheat starch,	. . . . .	20 ,,
British gum,	. . . . .	32 ,,

Boil, and then add

Acetate of iron, 24° Tw.,	. . . . .	3 gallons.

And when quite cold, add

Nitrate of iron, 80° Tw.,	. . . . .	1 gallon.

After the discharge colours have been printed on the dyed cloth, the pieces are passed in open width through a cistern fitted with rollers, over which the cloth travels up and down through a bath of a clear solution of bleaching liquor at 12° Tw., in which it remains for about one minute, and in coming out of the bath is nipped between rollers which remove the excess of liquor; it is then passed through water and well washed. Chalk or lime must be added to the chemic bath to neutralise any free acid that might get into the bath, for if this free acid is allowed to accumulate in the bath, free chlorine will be produced, and will so act on the cloth as to destroy the red ground altogether. The reaction which takes place in this process is the production of hypochlorous acid by the action of the tartaric acid on the bleaching powder, and this hypochlorous acid acts at once on the spot where the colour was printed.

In order to raise the lead yellows and greens, the cloth is next passed through a weak solution of bichromate of potash, which converts the lead salts into the yellow chromate of lead.

In the discharge style on indigo blue (see patterns 17 and 17A), the cloth is first dyed a plain indigo blue, then soured, washed, dried, and afterwards printed with the following colours:—

No. 17.—Discharge White.

Water,	. . . . .	16 gallons.
Bichromate of soda,	. . . . .	32 lbs.
Caustic soda,	. . . . .	8 ,,
Wheat starch,	. . . . .	24 ,,
Olive oil,	. . . . .	½ lb. Boil, &c.

This colour must be reduced for light shades of indigo, especially on blotchy patterns.

No. 18.—Discharge Yellow.

Water,	2 gallons.
Bichromate of soda,	16 lbs.
Caustic soda,	4 ,,
Dissolve, and add	
Lead yellow paste,	4 gallons.
12 ozs. gum tragacanth,	2 ,,
And when cold add	
6 lbs. blood albumen solution,	8 ,,

Lead Yellow Paste.

(*a*) In 40 gallons of hot water dissolve 343 lbs. white sugar of lead.
(*b*) In 40 gallons of hot water dissolve 147 lbs. bichromate of soda.

Add (*b*) to (*a*), wash by decantation, and filter to 15 gallons.

Blood Albumen Solution (6 lbs. per gall.).

Water at 130° F.,	20 gallons.
Dry blood albumen,	120 lbs.

Add about 1 lb. at a time, stirring well till dissolved, which will take about thirty minutes.

No. 19.—Discharge Red.

Water,	2 gallons.
Bichromate of soda,	16 lbs.
Caustic soda,	4 ,,
Dissolve, and add	
12 ozs. gum tragacanth,	2 gallons.
Vermilion,	120 lbs.
6 lbs. blood albumen solution,	8 gallons.

No. 20.—Discharge Green.

Water,	2 gallons.
Bichromate of soda,	16 lbs.
Caustic soda,	4 ,,
Dissolve, and add	
12 ozs. gum tragacanth,	2 gallons.
Guignet's pigment green paste,	80 lbs.
6 lbs. blood albumen solution,	8 gallons.

No. 21—Discharge Light Blue.

Discharge white,	2 gallons.
Starch thickening,	13 ,,
Prussian blue pulp,	1 gallon.

No. 22.—Discharge Brown.

Water,	2 gallons.
Bichromate of soda,	16 lbs.
Caustic soda,	4 ,,
Dissolve, and add	
12 ozs. gum tragacanth,	2 gallons.
6 lbs. blood albumen solution,	8 ,,
Pigment brown,	64 lbs.

No. 23.—Discharge Buff.

Water,	2 gallons.
Bichromate of soda,	16 lbs.
Caustic soda,	4 ,,
Dissolve, and add	
12 ozs. gum tragacanth,	2 gallons.
Pigment buff,	64 lbs.
6 lbs. blood albumen solution,	8 gallons.

By mixing or reducing the above stands, almost any required shade may be produced. The pigments are those usually sold for printing purposes; they must have been ground to a very fine pulp. Any pigment may be used which does not coagulate the albumen, and will stand the action of the "cutting liquor."

After the goods are printed they are passed through the "cutting liquor," which is contained in the box of the padding machine. The box of the padding machine is fitted up with copper rollers, three at the top and three at the bottom. The cloth passes up and down (by means of these rollers) in the cutting liquor, in which it remains for about ten seconds, and then immediately passes through several cisterns containing plenty of cold water in order to remove every trace of acid before the cloth is dried.

The cutting liquor is sulphuric acid at 10° Tw., containing 4 ozs. oxalic acid per gallon, and is kept at a temperature of 160° F.

The theory of this process is—1st, the formation of chromic acid by the action of the cutting liquor on the chromate of soda; 2nd, the action of the chromic acid on the indigo, changing the latter into soluble isatine; third, the fixation of the coloured pigments by the coagulation of the albumen. Much care and judgment must be exercised in this, as indeed in all branches of bleaching, dyeing, and printing, in order to obtain good results. The proper quantity of chromate of soda must be added to the printing colour according to the depth of shade of indigo to be discharged, as also the strength of pattern to be printed; for if enough chromic acid is not produced in the cutting bath the indigo will not be sufficiently discharged, and the results would be flat and poor shades. On the other hand, if too much chrome be used the cloth will be found to be tendered when it is dried, especially after it has been in use for a short time; this tendering of the cloth has been a source of great loss to many calico-printers, and many attempts have been made to avoid it; some add methylated spirits, sugar, glucose, starch, and many other things to the cutting liquor for this purpose, but nothing is so successful as carefully regulating the amount of chrome to the quantity of indigo to be discharged. Another source of trouble in this style is a "tailing" of the pattern (spreading of the pattern beyond its proper limits, especially in one direction); this tailing is not due to bad printing, but to too much chrome in the printing colour, or else to the

cutting liquor being too weak or too low in temperature, or, lastly, to the cloth being damp when entering the cutting liquor.

A white discharge on indigo can be produced by reversing the above process—that is, by first padding the indigo-dyed cloth on the padding mangle with a solution of bichromate of soda, 1 lb. per gallon; after drying, the following acid colour is printed on:—

No. 24.—12 oz.-12 oz. Acid.

Water,	15 gallons.
Wheat starch,	32 lbs.
Boil, stir till half cold, then add	
Oxalic acid,	12 lbs.
When quite cold, add	
Sulphuric acid,	12 lbs.
previously mixed with	
Water,	1 gallon.

This colour must be reduced for light shades of indigo. After the cloth is printed and not over-dried, it is well washed in warm water; coloured discharges cannot be obtained by this method.

A third method of discharging indigo is by means of red prussiate and a weak alkali—such as chalk, bicarbonate of soda, carbonate of magnesia, &c.—with or without addition of chlorate of soda; coloured discharges may be produced by this method. The following are a few examples:—

No. 25.—White Discharge.

Water,	14 gallons.
Red prussiate of potash,	32 lbs.
Wheat starch,	20 ,,
Colour oil,	½ gallon.
Boil, and stir till cold, then add	
Bicarbonate of soda,	8 lbs.

This colour will only discharge medium shades of indigo; for light shades, the colour may be reduced with starch paste; but for very dark shades the following may be used:—

No. 26.—White Discharge.

Water,	14 gallons.
Red prussiate of potash,	28 lbs.
Chlorate of soda,	4 ,,
Wheat starch,	20 ,,
Colour oil,	½ gallon.
Boil, stir till cold. then add	
Ground chalk,	8 lbs.

No. 27.—Yellow Discharge.

Red prussiate of potash	28 lbs.
Chlorate of soda,	4 ,,
Chromate of lead pulp,	80 ,,
Ground chalk,	8 ,,
12 ozs. gum tragacanth,	5 gallons.
6 lbs. blood albumen,	6 ,,
All to be ground together in a mill.	

By using vermilion, pigment brown, Guignet's green, &c., in place of the chromate of lead pulp in the above colour, almost any shade may be produced. After printing, the goods are steamed as for extract work.

The manganese bronze discharge has now given way to the more varied discharges on benzo-purpurine and allied dyestuffs (see patterns 29 and 31). By these new dyestuffs every possible shade of ground can easily be obtained (see Plain Dyes, p. 121). In this style a reducing agent is printed on the dyed cloth, which is then steamed in the ordinary steam box, the pieces being wound in clean greys, so as to prevent the direct action of steam and air, or better still, in a continuous or open steamer. The most useful reducing agent for this purpose is stannous acetate, as this substance not only destroys the ground colour where it is printed, but at the same time fixes many acid colouring matters, such as Persian berry extract, alizarine green, cœruline, &c., and so produces coloured discharges upon a coloured ground. The following are a few examples which may be varied infinitely:—

No. 28.—White Discharge.

Thickening for tin salts,	10 gallons.
Water,	2 ,,
Solution of stannous chloride (8 lbs. per gallon),	2 ,,
Solution of acetate of lime, 24° Tw.,	2 ,,

Mix cold.

No. 29.—Yellow Discharge.

Thickening for tin salts,	10 gallons.
Solution of stannous chloride (8 lbs. per gallon),	2 ,,
Acetate of lime, 24° Tw.,	2 ,,
Persian berry extract, 48° Tw.,	2 ,,

Mix cold.

No. 30.—Green Discharge.

Thickening for tin salts,	10 gallons.
Solution of stannous chloride (8 lbs.),	2 ,,
Acetate of lime, 24° Tw.,	2 ,,
Persian berry extract, 48° Tw.,	1 gallon.
Alizarine blue G., 20 per cent.,	½ ,,
Acetate of chrome, 32° Tw.,	½ ,,

Mix cold.

No. 31.—Brown Discharge.

Thickening for tin salts,	10 gallons.
Solution of stannous chloride (8 lbs.),	2 ,,
Acetate of lime, 24° Tw.,	2 ,,
Persian berry extract, 48° Tw.,	1¼ ,,
Alizarine for red, 20 per cent.,	⅜ gallon.
Acetate of chrome, 32° Tw.,	⅜ ,,

Mix cold.

Thickening for Tin Salts.

Water,	16 gallons.
Wheat starch,	32 lbs.
British gum,	16 ,,
Colour oil,	1 gallon.

Boil, and stir till cold.

These colours must be reduced for discharges on light ground shades; by mixing them with one another, or with other colouring matters, a great variety of coloured discharges may be obtained, which, if nicely carried out, are very effective.

The next style we will notice is that generally known as

THE EXTRACT STYLE.—In this style (see patterns 32 to 53) the mordants and colouring matters are mixed together and printed on the cloth in one operation, after which they are steamed in the steaming apparatus. In this steaming process great diversity of opinion prevails as to the best method of carrying out the operation. Sometimes the pieces are steamed as soon as printed, in other cases they are previously exposed to the air for some hours. The pressure, and, therefore, the temperature, varies from 1 or 2 lbs. to 10 or 20 lbs. on the square inch. The length of time during which the goods are exposed to the steam varies from thirty minutes to one or two hours. Another important point to be carefully regulated is the degree of moisture; if the steam is too wet the colours may run one into another, or swell beyond their proper limits—"run," as it is called. If the steam is too dry, the colours may not be properly developed, or may become uneven. The volume of steam escaping from the steam-chest must be sufficient—especially during the first twenty or thirty minutes—to carry off any vapours which might act injuriously on the colours themselves, or upon the cloth on which they are printed. On all these points experience and a careful observation of the results obtained under different conditions must be the guide. The extract style has become more prominent every year, with the more extensive use of the many-colour printing machines, and the very numerous discoveries of new colouring matters suitable for this style of printing. Though not quite so fast to soaping as the dyed style, the extract style gives far more beautiful effects of colouring, as can be seen in the splendid arrays of modern cretonnes.

As a rule, colours for the extract style are printed on cloth previously prepared with oleine oil. The cloth being passed for this purpose through a 5 per cent. solution of oleine, and dried on the padding mangle. By this means faster and brighter shades are produced. The following are some of the standard colours suitable for this style; but it is in styles like this, where a knowledge both of chemistry and also of the theory of colour (see pp. 128–132 in the article on colour) is so essential; for no matter how many recipes for standard colours one may have, the colourist will be continually called upon to produce still more shades to meet the requirements of this style, the very nature of which seems to demand an almost infinite variety of shades, and these can only be produced by an intelligent and judicious mixing of the standard colours.

No. 32.—Extract Red (Stand).

Extract Paste,	11 gallons.
Alizarine (20 per cent.),	2 ,,
Red mordant,	3 ,,

Mix cold.

No. 33.—*Extract Paste.*

Water,	13 gallons.
Wheat starch,	32 lbs.
8 ozs. gum tragacanth,	2 gallons.
Colour oil,	1 gallon.

Boil, and stir till cold.

This paste is to be used for all extract work unless otherwise stated.

8 ozs. Gum Tragacanth.

Water,	25 gallons.
Gum tragacanth,	20 lbs.

Steep in a barrel for forty-eight hours, then blow steam in, stirring occasionally for six hours, and make up to 40 gallons.

Red Mordant.

Sulpho-cyanide of alumina, 18° Tw.,	1 measure.
Acetate of lime, 24° Tw. (see recipe No. 13),	1 ,,
Citro-oxalate of tin,	1 ,,

Sulpho-Cyanide of Alumina, 18° Tw.

Sulpho-cyanide of barium,	40 lbs.
Sulphate of alumina,	24 ,,
Boiling water,	12 gallons.

Stir well for twenty minutes, let the sediment settle, and use the clear liquid.

Citro-Oxalate of Tin.

Stannic oxide pulp,	5 gallons.
Citric acid,	6 lbs.
Oxalic acid,	6 ,,

Make up to 16 gallons with water; dissolve cold.

Stannic Oxide Pulp for above.

(*a*) Tin crystals,	25 lbs.
Boiling water,	20 gallons.
Spirits of salts,	20 lbs.
Chlorate of soda (added a few ounces at a time whilst still hot),	4 ,,
(*b*) Common soda,	75 ,,
Hot water,	40 gallons.

Add (*b*) to (*a*), wash the precipitate, and filter to 5 gallons.

For yellowish-reds the yellow shade of alizarine must be used in the above recipe, and for bluer reds, of course, the blue shade of alizarine. For roses and pinks the red standard must be reduced with extract paste and water—say for roses, 2 Lt. to 4 Lt.; for pink, 8 Lt. to 16 Lt., or even lighter in some cases.

No. 34.—Extract Orange (Stand).

Extract paste,	11 gallons.
Alizarine orange (20 per cent.),	2 ,,
Red mordant,	3 ,,

Mix cold.

No. 35.—Extract Yellow (Stand).

Thickening for tin salts,	12 gallons.
Persian berry extract, 48° T.,	2 ,,
Solution of stannous chloride (6 lbs. per gallon),	½ gallon.
Red mordant,	1½ gallons.

Mix cold.

Thickening for Tin Salts.

Water,	15 gallons.
Wheat starch,	32 lbs.
Colour oil,	1 gallon.

Boil, and stir till cold.

No. 36.—Extract Bronze (Stand).

Extract paste,	12 gallons.
Persian berry extract, 48° Tw.,	2 ,,
Chrome mordant,	2 ,,

Mix cold.

No. 37.—Extract Slate (Stand).

Extract paste,	12 gallons.
Alizarine green, 20 per cent.,	2 ,,
Chrome mordant,	2 ,,

Mix cold.

Chrome Mordant.

Acetate of chrome, 32° Tw.,	12 gallons.
Acetate of lime, 24° Tw.,	4 ,,

No. 37*a*.—Acetate of Chrome (*First Method*).

(*a*)	Water,	10 gallons.
	Sulphuric acid,	10 lbs.
	Bichromate of potash,	30 ,,
(*b*)	Acetic acid, 50 per cent.,	6 gallons.
(*c*)	Hot water,	5 ,,
	Brown sugar,	10 lbs.

Heat (*a*) in a 40-gallon pan nearly to the boil, then add (*b*) and (*c*), about half a gallon at a time, so as to keep up a vigorous ebullition, without allowing it to boil over; continue until all is added; then empty into a 40-gallon cask and allow to remain till cold, when, if all is right, a few drops poured into a solution of acetate of lead will give a pure white precipitate.

No. 37*b*.—Acetate of Chrome (*Second Method*).

(*a*)	Boiling water,	20 gallons.
	Chrome alum,	40 lbs.
(*b*)	Hot water,	10 gallons.
	Soda ash,	14 lbs.

Add (*b*) to (*a*), wash the precipitate, and drain or use the filter press; then dissolve in acetic acid, 50 per cent., 3 gallons, and set at 32° Tw.

No. 37*c*.—Acetate of Chrome (*Third Method*).

(*a*)	Boiling water,	10 gallons.
	Chrome alum,	80 lbs.
(*b*)	Boiling water,	10 gallons.
	White acetate of lead,	80 lbs.

Add (*b*) to (*a*), stir well, let the sediment settle, decant the clear liquor (which is the acetate of chrome), and dilute to 32° Tw.

No. 38.—Extract Claret (Stand).

Extract paste,	12 gallons.
Alizarine, 20 per cent.,	2 ,,
Chrome mordant,	2 ,,

Mix cold.

No. 39.—Extract Blue (Stand).

Extract paste,	12 gallons.
Alizarine blue, 20 per cent.,	1½ ,,
Alkaline blue (8 ozs. per gallon),	½ gallon.
Chrome mordant,	2 gallons.

Mix cold.

No. 40.—Extract Violet (Stand).

Extract paste,	11 gallons.
Alizarine-cyanine, 20 per cent.,	2 ,,
Red mordant,	3 ,,

Mix cold.

No. 41.—Extract Black.

Water,	3 gallons.
Chlorate of soda,	2 lbs.
Logwood extract, 12° Tw.,	8 gallons.
Acetic acid, 30 per cent.,	½ gallon.
Colour oil,	½ ,,
Wheat starch,	20 lbs.
British gum,	8 ,,

Boil, and stir till cold, then add

Acetate of chrome, 32° Tw.,	2 gallons.

No. 42.—Aniline Black (for Steaming).

Yellow prussiate of soda,	12 lbs.
Chlorate of soda,	6 ,,
Water,	12 gallons.
Wheat starch,	18 lbs.
British gum,	8 ,,
Colour oil,	½ gallon.

Boil, and stir till cold, then add

Aniline salts,	18 lbs.

Many other "stands" might have been given for this style of work; but as the author's aim is to reduce everything to the simplest possible condition (as by this means mistakes are often avoided, which is not the case where more complex and more numerous "stands" are worked), the intelligent colourist will find these "stands" quite sufficient for the production of an almost infinite variety of shades. The following are given as a few examples:—

No. 43.—Medium Brown.

Extract bronze (stand),	13 gallons.
,, claret (stand),	3 ,,

No. 44.—Tan Shade.

3 Lt. off medium brown.

No. 45.—Buff Shade.

12 Lt. off medium brown.

No. 46.—Medium Olive.

Extract paste,		10 gallons.
,,	bronze (stand),	3 ,,
,,	slate (stand),	3 ,,

No. 47.—Brown Olive.

Extract paste,		9 gallons.
,,	bronze (stand),	4 ,,
,,	slate (stand),	2 ,,
,,	claret (stand),	1 gallon.

No. 48.—Green Olive.

Extract paste,		9 gallons.
,,	bronze (stand),	3 ,,
,,	slate (stand),	2 ,,
,,	blue (stand),	2 ,,

No. 49.—Yellow Olive.

Extract paste,		6 gallons.
,,	bronze (stand),	8 ,,
,,	slate (stand),	2 ,,

No. 50.—Old Gold.

Extract paste,		4½ gallons.
,,	bronze (stand),	11 ,,
,,	slate (stand),	½ gallon.

No. 51.—Salmon.

Extract paste,		8 gallons.
,,	orange (stand),	4 ,,
,,	bronze (stand),	4 ,,

No. 52.—Terra-Cotta.

Extract paste,		8 gallons.
,,	red (stand),	4 ,,
,,	bronze (stand),	4 ,,

No. 53.—Chocolate.

Extract red (stand),		8 gallons.
,,	claret (stand),	6 ,,
,,	slate (stand),	2 ,,

It will be observed that all the above colours contain acid colouring matters, and are, therefore, fixed with a basic mordant. They stand light and soaping fairly well.

The basic colouring matters are often used for the extract style of colours (see patterns Nos. 54 to 60), but these do not stand light nearly so well as the acid colours, many of them fading in a few days if exposed

to direct sunlight; nor do they stand soaping unless combined with such poisonous substances as arsenic or antimony, which is a decided drawback to the use of the basic colouring matters; otherwise these basic colouring matters would be very useful, as they produce some of the brightest shades that it is possible to obtain. The following examples will illustrate the composition of the colours containing basic colouring matters. Tannic acid is given as the fixing agent, as the use of arsenic paste ought to be condemned as injurious to the health both of the workmen who have to produce the goods, and of the public who have to handle them :—

No. 54.—3 ozs. Methylene Blue.

Methylene blue,	3 lbs.	
Water,	3 gallons.	
Acetic acid, 30 per cent.,	2 ,,	dissolve, and add
Water,	8 ,,	
Wheat starch,	18 lbs.	
Colour oil,	½ gallon.	
Boil, and stir till cold, then add		
Tannin paste,	3 gallons.	

No. 55.—*Tannin Paste.*

Water,	12 gallons.
Tannic acid crystals,	96 lbs.
Tartaric acid,	8 ,,
British gum,	48 ,,
Boil and stir till dissolved.	

No. 56.—3 ozs. Methyl Green.

Methyl green,	3 lbs.	
Water,	3 gallons.	
Acetic acid, 30 per cent.,	2 ,,	dissolve, and add
Water,	8 ,,	
Wheat starch,	18 lbs.	
Colour oil,	½ gallon.	
Boil, and stir till cold, then add		
Tannin paste,	1 ,,	
Sumach extract, 48° Tw.,	2 gallons.	

No. 57.—2 ozs. Auramine Yellow.

Auramine yellow,	2 lbs.	
Water,	3 gallons.	
Acetic acid,	2 ,,	dissolve, and add
Water,	9 ,,	
Wheat starch,	18 lbs.	
Colour oil,	½ gallon.	
Boil, and stir till cold, then add		
Tannin paste,	2 gallons.	

No. 58.—2 ozs. Bismarck Brown.

Bismarck brown,	2 lbs.	
Water,	3 gallons.	
Acetic acid,	2 ,,	dissolve, and add
Water,	9 ,,	
Wheat starch,	18 lbs.	
Colour oil,	½ gallon.	

Boil, stir till cold, then add

Gall extract, 48° Tw.,	2 gallons.	

No. 59.—½ oz. Safranine Pink.

Safranine,	½ lb.	
Water,	4 gallons.	
Acetic acid,	1 gallon,	dissolve, and add
Water,	10 gallons.	
Wheat starch,	18 lbs.	
Colour oil,	½ gallon.	

Boil, stir till cold, then add

Tannin paste,	1 ,,	

No. 60.—2 ozs. Methyl Violet.

Methyl violet,	2 lbs.	
Water,	2 gallons.	
Acetic acid, 30 per cent.,	2 ,,	dissolve, and add
Water,	10 ,,	
Wheat starch,	18 lbs.	
Colour oil,	½ gallon.	

Boil, and stir till cold, then add

Tannin paste,	1 ,,	
Sumach extract, 48° Tw.,	1 ,,	

After printing, drying, and steaming, it is usual to pass goods containing basic anilines in their colourings through a solution of an antimony salt containing 1 to 2 per cent. of the double tartrate or the double oxalate of antimony and potash, or of the fluoride of antimony. The addition of 1 per cent. of ground chalk will prevent the antimony bath from becoming too acid by neutralising the free acid liberated from the antimony salt, as the base of the latter combines with the colour lake to form a more complex compound of the tannate of antimony and colour base. It is no doubt owing to the greater complexity of these double tannates of a metal and colour base that they resist the action of light and washing better than is the case if the antimony bath is not given. Most likely the same explanation holds good to a great extent with respect to the action of oleine oil upon the colour lake formed in the case of the combination of the acid colouring matters with a mineral base; in these latter it is a double compound of a mineral base with a colour acid and a fatty acid. It may perhaps be as well to observe here that the base oxide of chromium forms a more permanent combination with the colour acids than is the case with alumina, especially with regard to the action of soaping upon these colour lakes; this is most likely owing to the fact that alumina is soluble in caustic soda, whilst the

oxide of chromium is not. Hence, when soaping goods printed in the extract style we must be careful to select a soap containing very little free alkali. It is in this soaping process after the goods have been printed and steamed that so many failures are made in the extract style. Of course it will be evident that in combinations which must be soaped there must be no very loose colours, or they would be almost entirely removed in the soaping process. But even those colours which are considered moderately fast will not stand a rash and severe treatment with an alkaline soap. As one of the chief objects of soaping in this style of work is to remove the thickening used in the printing colour, some printers prefer to steep the goods before soaping in a bath of malt liquor, kept at a temperature of about 140° F., which has the power of converting starch into sugar, and thus rendering it more soluble in water, and, therefore, the more easily removed from the cloth without taking the colours with it; after this treatment a very slight soaping, especially in the open soaper, is sufficient to brighten up the colours to the desired extent. Some colourists print the goods in a much darker colour than is necessary and afterwards soap down the colour to the shade required; but this is a bad practice, as some colours come down very much more than others in soaping, and where there are a number of colours in a combination, in getting one or two of the colours down to the required shade others may be brought too low and so spoil the effect.

Pigments or Pigment Colours.—Another class of colours that may be used for the steam or extract style are the so-called pigments or pigment colours (see patterns Nos. 61 to 65). These are generally coloured minerals very finely ground, and fixed upon the cloth by means of a solution of albumen. For dark and flat shades blood albumen is generally used, but for light and bright colours egg albumen (owing to its greater transparency) is the best. The albumen acts both as the thickening agent and also as the mordant, and as it coagulates at a temperature of about 70° C. the water used for dissolving it should not be above 50° C. Below are a few recipes for the pigment colours.

No. 61.—3 lbs. Blue (Stand).

Ultramarine blue,	48 lbs.
Water,	5 gallons.
Mix, and add	
8 ozs. gum tragacanth,	2 gallons.
6 lbs. blood albumen solution,	7 ,,
Mix cold.	

No. 62.—4 lbs. Green (Stand).

Pigment green pulp,	64 lbs.
Water,	3 gallons.
Mix, and add	
8 ozs. gum tragacanth,	2 gallons.
6 lbs. blood albumen solution,	7 ,,
Mix cold.	

No. 63.—2 lbs. Aniline Grey (Stand).

Aniline grey,	32 lbs.
Water,	4 gallons.

Mix, and add

8 ozs. gum tragacanth,	3 gallons.
6 lbs. blood albumen solution,	7 ,,

Mix cold.

No. 64.—4 lbs. Lead Yellow (Stand).

Lead Yellow,	64 lbs.
Water,	2 gallons.

Mix, and add

8 ozs. gum tragacanth,	2 gallons.
6 lbs. blood albumen solution,	9 ,,

Mix cold.

No. 65.—6 lbs. Vermilion Red (Stand).

Vermilion,	96 lbs.
Water,	3 gallons.

Mix, and add

8 ozs. gum tragacanth,	2 gallons.
6 lbs. blood albumen solution,	9 ,,

Mix cold.

From the above "stands" a great variety of shades may be produced by reducing and mixing; although expensive, these colours are very much used, as they are very fast, especially to light. The pigment colours are fixed by steaming, and only require a slight soaping after, to remove any odour of albumen; but the following colours, which may also be used in the steam style, require to be passed through a solution of bichrome in order to develop or raise the colours, and are, therefore, spoken of as

Chromed or Raised Colours (see patterns Nos. 66 to 71)—

No. 66.—2 lbs. Catechu Brown (Stand).

Catechu liquor,	9 gallons.
Red liquor, 16° Tw.,	4 ,,
Gum Senegal,	40 lbs.

Boil till dissolved, then add

Alum,	4 lbs.
Chlorate of potash,	4 ,,

Stir till cold, then add

Oxalic acid,	1 lb.
In hot water,	½ gallon.

Catechu Liquor.

Water,	6 gallons.
Acetic acid, 30 per cent.,	1 gallon.
Catechu,	32 lbs.

Boil three hours, then make up to 9 gallons.

No. 67.—4 lbs. Lead Yellow (Stand).

White sugar of lead,	64 lbs.
Water,	16 gallons
Wheat starch,	24 lbs.

Boil, and stir till cold.

No. 68.—6° Tw. Iron Buff (Stand)

Acetate of iron, 24° Tw.,	4 gallons.
Water,	12 ,,
Wheat starch,	24 ,,

Boil, &c.

No. 69.—2 lbs. Prussiate Blue (Stand).

Water,	9 gallons.
Sal-ammoniac,	3 lbs.
Wheat starch,	24 ,,
Colour oil,	1 quart.

Boil, and add

Yellow prussiate of soda, in fine powder,	24 lbs.
Red prussiate of potash, ,, ,,	8 ,,
Prussiate of tin pulp,	6 gallons.

And when cold, add

Oxalic acid,	1 lb.
In water,	½ gallon.
Sulphuric acid,	2 lbs.
Mixed with cold water,	½ gallon.

Prussiate of Tin Pulp.

(*a*) Tin crystals,	22 lbs.
Dissolved in water,	40 gallons.
(*b*) Yellow prussiate of potash,	20 lbs.
Dissolved in water,	40 gallons.

Add (*b*) to (*a*), stirring well all the time, let the precipitate settle, wash precipitate, and filter down to 16 gallons.

No. 70.—Prussiate Green (Stand).

2 lbs. prussiate blue (stand),	12 gallons.
Extract paste,	2 ,,
Persian berry extract, 48° Tw.,	1 gallon.
Acetate of chrome, 32° Tw.,	1 ,,

No. 71.—Prussiate Olive (Stand).

2 lbs. prussiate blue (stand),	6 gallons.
Chrome black,	2 ,,
Extract paste,	4 ,,
Persian berry extract, 48° Tw.,	2 ,,
Acetate of chrome, 32° Tw.,	2 ,,

Chrome Black.

Same as steam aniline black, p. 51.

By reducing and mixing these stands a great variety of shades may be produced, but after steaming they will all require a passage through a solution of bichrome of about 2 ozs. per gallon of water (in order to raise the colours), and then a good wash in water to remove the chrome. In addition to the above there are many colours in use which do not come under any particular group, and to give recipes for all of them would very much increase the size of this volume without adding to its usefulness, but the following are a few of the more important of recent introduction :—

No. 72.—Indigo Blue (for direct printing).

(*a*)	8 oz. gum tragacauth,	4 gallons.
	Glucose,	6 quarts.
	Mix and strain.	
(*b*)	Well ground indigo,	10 lbs.
	8 lbs. caustic stand,	2½ gallons.

8 lbs. Caustic Stand.

8 lbs. dry caustic soda to 1 gallon water.

Mix and strain through a fine sieve. When cold, add (*b*) to (*a*) just before printing.

For darker shades decrease the quantity of thickening, and for lighter shades use more.

This colour must be printed from a doctor box with not too much pressure on the printing roller.

The drying tins must be lapped to prevent over-drying, the cloth must be left quite damp, and must be steamed immediately after printing, otherwise the caustic soda in the colour will be converted into carbonate, and so prevent the proper reduction and fixing of the indigo. The steaming box is a specially constructed one placed immediately behind the drying tins of the printing machine, thus enabling the steaming to be proceeded with at once, without having to remove the printed cloth, which would not bear handling in the damp state in which it leaves the drying tins. If everything is right, thirty seconds in the steamer is sufficient to fix the indigo. After steaming the goods are hung up on rails and exposed to the air for twenty-four hours before washing off.

No. 73.—Artificial Indigo.

This is not much used on account of its high price.

Water,	4 gallons.
Starch,	6 lbs.
Colour oil,	1 quart.
Boil, and add	
Powdered borax,	6 lbs.
And when cold, add	
Propiolic acid, 20 per cent. paste,	32 ,,
Xanthate of soda,	4 ,,

1 oz. methylene blue in ½ gallon water.

Print, dry, hang for twenty-four hours in warm room, then pass through soda solution, soap, and wash. The only advantage of this colour over indigo is that it may be printed along with other colours.

No 74.—Indophenol Blue.

Indophenol powder,	6 lbs.
Solution of stannous chloride (8 lbs. per gallon),	2 gallons.
Acetate of lime, 24° Tw.,	2 ,,
Acetic acid,	2 ,,
British gum,	24 lbs.

Heat to 120° F. and let stand all night. Print, dry, steam for one hour, then pass through solution of bichromate of soda (1 oz. per gallon).

No. 75.—Indigen Blue.

Citric acid,	4 lbs.
Alcohol,	½ gallon.
Indigen blue paste,	12 lbs.
Starch thickening,	8 gallons.
Tannic acid (10 lbs. per gallon),	1 gallon.

Print, dry, steam for one hour, and fix with tartar-emetic as usual, before soaping.

No. 76.—Indulin Blue.

Indulin blue paste,	12 lbs.
Ethyl tartrate,	1 gallon.
Starch thickening,	8 gallons.
Tannic acid (10 lbs. per gallon),	1 gallon.

Print, and steam for one and a-half hours without pressure; after steaming pass through a chalk bath, then malt and soap.

No. 77.—Gallocyanine Violet (L. Durand, Huguenin & Co.)—Dye-Way.

Mordant.

80 parts bichromate of potash, dissolved in
100 ,, water.
60 ,, liquid ammonia.

80 ,, hyposulphite of soda, dissolved in
200 ,, tragacanth thickening.

50 ,, acetate of magnesia, dissolved in
200 ,, tragacanth thickening.

Sieve the three solutions and mix them together, print, steam for two hours, wash, and for 100 yards dye in 4½ ozs. gallocyanine insoluble powder. Start cold, and raise to 160° F. in one hour, and keep this temperature for thirty minutes more. Give very light soaping, and finish with light chloring to clear the whites.

No 78.—Fast Myrtle (L. Durand, Huguenin & Co.)—Dye-Way.

Mordant.

The cloth is mangle-padded with the following mixture:—

20 parts gum Senegal (6 lbs. per gallon).
50 ,, water.
10 ,, acetic acid, 10° Tw.
30 ,, pyrolignite of iron, 24° Tw.
2 ,, sal-ammoniac.

Dry in a hot flue, then print on.

Lime juice discharge.

Lime juice, 24° Tw.,	8 gallons.
British gum,	40 lbs.

Steam for five minutes in a Mather & Platt's apparatus, and dung in the usual way; then for every 100 yards of cloth dye with 4 lbs. fast myrtle paste, and proceed as in last recipe.

No. 79.—Fast Myrtle. Print on.

200 parts fast myrtle paste.
250 ,, acetic acid, 10° Tw.
32 ,, nitrate of iron, 100° Tw.
32 ,, acetate of magnesia, 50° Tw.
25 ,, chlorate of potash.
630 ,, tragacanth thickening.
32 ,, acetate of chrome, 32° Tw.
Print, steam for one hour, soap at 120° F.

No. 80.—Chrome Violet.

Thickening, ...	8 gallons.
Chrome violet (Bayer & Co.'s), ...	16 lbs.
Acetate of chrome, 32° Tw., ...	½ gallon.

No. 81.—Chrome Blue.

Thickening, ...	8 gallons.
Chrome blue (Bayer & Co.'s), ...	16 lbs.
Acetate of chrome, 32° Tw., ...	½ gallon.

No. 82.—Chrome Green.

150 parts chrome green (Bayer & Co.'s) to be dissolved in
220 ,, of warm water.
550 ,, thickening.
80 ,, acetate of chrome, 32° Tw.

No. 83.—Chrome Yellow.

150 parts chrome yellow (Bayer & Co.'s).
770 ,, thickening.
80 ,, acetate of chrome, 32° Tw.

The last four colours are very bright (for colours fixed with chrome); they should be printed on oiled cloth, and steamed for one hour at 3 or 4 lbs. pressure.

No. 84.—Brilliant Yellow.

Extract paste, ...	8 gallons.
Brilliant yellow (Alph. Huillard & Co.), . . .	8 lbs.
Acetate of chrome, 32° Tw., ...	1 gallon.

Print, steam, and soap.

No. 85.—Brilliant Alizarine Blue G.

Extract paste, ...	8 gallons.
Brilliant alizarine blue G (Bayer & Co.'s), . . .	8 lbs. paste.
Acetate of chrome, 32° Tw., ...	½ gallon.

Print on oiled cloth, steam for one hour, pass through chalk bath, soap, wash, and dry.

The Insoluble Diazo-Colours.—When aniline hydrochloride is treated with a solution of sodium nitrite and hydrochloric acid, the following reaction takes place :—

$C_6H_5NH_2HCl$	+	$NaNO_2$	+	HCl	=	$C_6H_5N:NCl$	+	$NaCl$	+	$2H_2O$.
Aniline Hydrochloride.		Sodium Nitrite.		Hydrochloric Acid.		Diazo-benzene Chloride.		Sodium Chloride.		Water.

If this diazo-compound of aniline be added to an alkaline solution of beta-naphthol, an insoluble scarlet coloured compound is formed, thus—

$$\underset{\text{Diazo-benzene Chloride.}}{C_6H_5N{:}NCl} + \underset{\text{Beta-naphthol.}}{C_{10}H_7OH} + \underset{\text{Sodium Hydrate.}}{NaHO} = \underset{\text{Scarlet Compound.}}{C_6H_5N{:}NC_{10}H_6OH} + \underset{\text{Sodium Chloride.}}{NaCl} + \underset{\text{Water.}}{H_2O}.$$

Now, as previously explained, an insoluble compound can only be fixed upon cloth by means of albumen, or some similar substance, and this is sometimes done; but generally another method altogether is adopted—viz., the colour is developed directly upon the cloth, and, being insoluble, remains fixed there. A large number of patents have been taken out during the last fifteen years by Messrs. Read Holliday & Sons; Meister, Lucius & Brüning; the Actien Gesellschaft für Anilin-Fabrikation, and other colour makers, for the production of these insoluble diazo-colouring matters directly upon the cotton fibre. Several methods have been proposed, but the following is the best for producing the diazo-colours upon cotton piece goods:—

(1) The goods are "bottomed" by padding through an alkaline solution of beta-naphthol, or alpha-naphthol, on the padding machine (Fig. 12), and dried at a low temperature (about 100° F. to 150° F.).

(2) Immediately after being padded, the goods are printed with a thickened solution of the diazotised amine. The following are some of the colours produced by diazo-compounds upon alpha- and beta-naphthols:—

On Alpha-Naphthol Ground.	Beta-Naphthol Ground.	Diazo-Compound.
Reddish-brown.	Orange.	Aniline.
Yellow- ,,	Yellow-orange.	Meta-nitraniline.
,, ,,	Scarlet-red.	Para-nitraniline.
Puce.	Dark ,,	Amidoazo-benzol.
,,	Bordeaux.	Alpha-naphthylamine.
,,	Turkey red.	Beta-naphthylamine.
Dark brown.	Puce.	Benzidine.
,, violet.	Violet.	Dianisidine.
,, ,,	Blue.	Dianisidine, with chloride of copper.
Red.	Orange-red.	Xylidine.

In practice many precautions have to be taken to get good results. In the first place, the goods should not be bottomed with the alkaline naphthol solutions long before they are wanted for printing, nor should they be dried at too high a temperature, or exposed to the direct sunlight, for the grounds easily deteriorate, owing to most of the diazo-compounds being very unstable, and decomposing easily on standing any length of time, especially if allowed to become warm; on this account it is necessary to use ice-cold water when making up the colours in summer time. The following are a few of the best direct prints by this method:—

No. 86.—Para-nitraniline Red (Meister, Lucius & Brüning).

Prepare a naphthol grounding by padding the cloth with

1½ lbs. beta-naphthol in
¼ gallon soda lye, 36° Tw., add
10 gallons water and
½ gallon oleine oil.

Dry at a low temperature, and print on the following as soon as convenient.

Printing Colour.

1 gallon water.
½ ,, gum tragacanth (1 lb. per gallon).
1 quart acetic acid.
3 lbs. wheat starch. Boil well, cool, and, when quite cold, add
2 ,, crystallised acetate of soda. Add
1 oz. para-nitraniline (powder) dissolved in
1 quart hydrochloric acid, 36° Tw., by boiling, then add
1 ,, of water, cool, and add
1 lb. of broken ice, then add
½ oz. nitrite of soda dissolved in
½ gallon water.*

After printing, dry, wash, and soap, and wash again.

No. 87.—Amidoazo-benzol Dark Red (Meister, Lucius & Brüning).

Ground with beta-naphthol (as above) and print with *Printing Colour* as follows:—

1 gallon water.
½ ,, gum tragacanth (1 lb. per gallon).
3 lbs. wheat starch.
1 quart acetic acid. Boil well, cool, and add
1 lb. crystallised acetate of soda, and, when quite cold, add
1½ lbs. amidoazo-benzol N, dissolved in
½ gallon water.
1 pint hydrochloric acid, 36° Tw.; cool, and add
12 ozs. nitrite of soda dissolved in
½ gallon water.

Print, dry, soap, and wash.

No. 88.—Alpha-naphthylamine Bordeaux.

Ground with beta-naphthol as above, and print with the following:—

1 gallon water.
½ ,, gum tragacanth.
¼ ,, acetic acid.
3 lbs. wheat starch; boil well, cool, and add
1½ lbs. acetate of soda, and when quite cold add
8 ozs. alpha-naphthylamine melted with
½ gallon hot water.
3 gills hydrochloric acid, 36° Tw. Stir well, and add
2 lbs. of crushed ice; keep stirring, and add
4 ozs. nitrite of soda dissolved in
1 lb. water.
1 lb. ice.

Print, dry, soap, and wash.

* *N.B.*—The bracket indicates that the substances enclosed must be mixed together first before they are added to the remainder.

No. 89.—Dianisidine Blue.

Ground with beta-naphthol, and print with the following :—

1 gallon water.
½ ,, gum tragacanth.
¼ ,, acetic acid.
3 lbs. wheat starch ; boil well, cool, and add
1 lb. acetate of soda, and when quite cold add
4 ozs. dianisidine.
7 ozs. hydrochloric acid, 36° Tw.
3 quarts water.
1½ lbs. crushed ice ; then run in slowly
1 lb. nitrite of soda dissolved in
½ gallon water ; and lastly, add
1 gill of chloride of copper, 70° Tw.

Print, dry, soap, and wash.

No. 90.—Azo-Turkey Red (K. Oehler).

3 lbs. 2¾ ozs. β-naphthol dissolved in
3 lbs. 8½ ozs. of caustic soda solution, 64° Tw.
3½ gallons water.
2 ,, gum mucilage.

The goods are first printed in this colour, and, after cooling, immediately passed through the following

Preparation of Diazo Solution.

3 lbs. 2½ ozs. of finely-ground β-naphthylamine.
2 lbs. 7 ozs. of hydrochloric acid, 32 per cent.
44 lbs. water. Boil a quarter of an hour, and stir till quite cold, then add
4 lbs. 13¾ ozs. hydrochloric acid, 32 per cent.
20 lbs. of ice or cold water, to reduce the temperature to 34° F., then add
1 lb. 11 ozs. of nitrite of sodium, 96 per cent., dissolved in
11 lbs. water, run into the cold mixture slowly through a long funnel reaching to the bottom of the mixing vessel, keeping the mixture well stirred all the time, and the temperature below 40° F., with ice if necessary.
Next add a solution of 5 lbs. of pure acetate of sodium, and make the mixture up to 220 lbs. with cold water.

This diazo solution will keep good only a very short time (two or three hours), and must be kept cold. After printing in the naphthol colour and padding in the diazo solution, the goods are to be washed in water, then soaped, and finally washed and dried.

Resists or reserves are obtained in this style by printing on the material, previously prepared with the alkaline solution of naphthol, a body which will react on the diazo-compound, and thus prevent the formation of coloured compounds. The substance most effective for this purpose is stannous chloride (tin crystals). The change which takes place in the constitution of these compounds, and which prevents the formation of colour with the naphthol, is represented by the following equation :—

$$\underset{\text{Diazo-benzene Chloride.}}{C_6H_5N : NCl} + \underset{\text{Stannous Chloride.}}{2SnCl_2} + \underset{\text{Hydrochloric Acid.}}{3HCl} = \underset{\text{Phenylhydrazine.}}{NH_2 - NH - C_6H_5} + \underset{\text{Stannic Chloride.}}{2SnCl_4}.$$

No. 91.—White Reserve.

The material is prepared as above with the beta-naphthol solution, and dried; then print on the following:—

1 gallon gum solution (1 in 1).
10 lbs. tin crystals.
5 lbs. oxide of tin paste.

Dry at a low temperature, and then pass into a developing bath made as follows:—

5½ lbs. para-nitraniline N (Meister, Lucius & Brüning).
½ gallon water.

Place ice in this mixture, and pour in slowly, with constant stirring, ½ gallon hydrochloric acid, filter if required, and add cold water to make up to 8 gallons; then add a solution of 7½ lbs. sodium acetate in 2 gallons of water. Work the goods in this bath for a short time. Wash, soap for ten minutes at 60° C., then rinse, and dry.

No. 92.—Blue Reserve under Para-nitraniline Red.

Prepare the goods as above with the beta-naphthol, then print on the following:—

1 lb. 6 ozs. dianisidine salt (Meister, Lucius & Brüning).
1 lb. hydrochloric acid, 36° Tw.
2½ gallons water and ice to reduce to 0° C., then add
12 ozs. sodium nitrite in
½ gallon water, and
3 lbs. chloride of copper, 70° Tw.

Make up to 5 gallons with cold water, and add to the following thickening:—

2½ gallons water.
½ gallon acetic acid, 9° Tw.
2 gallons gum tragacanth (1 lb. per gallon).
10 lbs. wheat starch; boil well, and cool; just before printing add
4 lbs. ammonium persulphate.

Red Developing Bath.

1 lb. 6 ozs. para-nitraniline extra, dissolved in
2½ gallons water.
1 gallon gum tragacanth (8 ozs. per gallon).
5 gallons ice water.
2 lbs. oxalate of ammonia in
1½ gallons water, and
3 lbs. acetate of soda crystals.

The red developer should be padded on with a padding mangle, of which only the lower roller, which dips into the developer, is evenly lapped with cloth. When leaving the wringing rollers the goods pass a system of syringes, and a vat with running water. After a good wash they are soaped broadwise with

¾ oz. soap.
⅜ oz. oxalate of ammonia to each gallon of water.

No. 93.—Yellow Reserve.

Print the following on goods prepared with naphthol; dry well; then pass through the developing solution, and wash well:—

1 gallon of water.
3 pints acetic acid, 12° Tw.
4 lbs. wheat starch; boil well, and add
1 lb. auramine conc. (Meister, Lucius & Brüning) in
½ gallon acetic acid,
1 pint glycerine; and when cold add
3 lbs. tartaric acid,
3½ lbs. acetic-tannic acid solution (1 in 1); and
6 lbs. tin crystals,
2 lbs. oxide of tin paste in
½ gallon gum solution (1 in 1).

No. 94.—Green Reserve.

Print the following on goods prepared with naphthol; dry, and pass through developing solution; wash well:—

1 gallon water.
3 pints acetic acid.
4 lbs. wheat starch. Boil well, and add
14 ozs. brilliant green crystals, in
3 pints acetic acid,
2 lbs. tartaric acid,
1 pint glycerine, and when cold, add
3 lbs. acetic-tannic acid solution (1 in 1),
3 ,, acetate of tin, 36° Tw.

Preparation of Acetate of Tin Solution of 36° Tw.

Solution (*a*) 12 lbs. tin crystals, dissolved in
1 gallon acetic acid.
1½ ,, water.

Solution (*b*) 12 lbs. white sugar of lead, in
1 gallon acetic acid.
1½ ,, water.

Add (*a*) to (*b*) hot, during constant stirring, cool, allow to settle, and filter off from the chloride of lead.

No. 95.—Gallazine Blue.

Extract paste,	8 gallons.
Gallazine A (Durand, Huguenin & Co.),	16 lbs.
Acetate of chrome, 32° Tw.,	½ gallon.

Print, steam for one hour, and soap lightly.

No. 96.—Azo-Green.

Extract paste,	8 gallons.
Azo-green paste (Bayer & Co.),	16 lbs.
Acetate of chrome, 32° Tw.,	½ gallon.

No. 97.—Diamond Yellow.

Extract paste,	8 gallons.
Diamond yellow paste (Bayer & Co.),	10 lbs.
Acetate of chrome, 32° Tw.,	½ gallon.
Acetate of lime, 24° Tw.,	¼ ,,

No. 98.—Diamond Orange.

Extract paste,	8 gallons.
Diamond orange (Bayer & Co.),	12 lbs.
Acetate of chrome, 32° Tw.,.	½ gallon.

The above three colours are to be printed on oiled cloth, steamed for one hour at 2 or 3 lbs. pressure, passed through a chalk bath at 168° F., then malted and soaped.

No. 99.—Brilliant Chrome Red.

Extract paste,	8 gallons.
Brilliant chrome red (Bayer & Co.),	16 lbs.
Acetate of chrome, 32° Tw.,	½ gallon.

No. 100.—Chrome Rubine.

Extract paste,	8 gallons.
Chrome rubine (Bayer & Co.),	10 lbs.
Acetate of chrome, 32° Tw.,	½ gallon.

The above two colours are to be printed on oiled cloth, steamed for one hour with pressure, then passed through a chalk bath, malted, and soaped.

No. 101.—Alizarine Cyanine Black.

Extract paste,	8 gallons.
Alizarine cyanine black (Bayer & Co.),	16 lbs.
Acetate of chrome, 32° Tw.,	½ gallon.
Acetate of lime, 24° Tw.,	¼ ,,

No. 102.—Blue Grey.

Extract paste,	8 gallons.
Alizarine cyanine black G (Bayer & Co.),	4 lbs.
Acetate of chrome, 32° Tw.,	1 quart.
Acetate of lime, 24° Tw.,	1 pint.

Print on oiled cloth, steam for one hour at 7 lbs., chalk, malt, and soap at 90° F.

No. 103.—Dark Grey.

Extract paste,	8 gallons.
Sterosine grey (Read Holliday & Sons),	½ gallon.
Acetate of chrome, 32° Tw.,	½ ,,

No. 104.—Light Grey.

Extract paste,	8 gallons.
Sterosine grey,	1 pint.
Acetate of chrome, 32° Tw.,	1 ,,

Print on oiled cloth, and steam at 2 or 3 lbs. pressure.

The following are new colours for discharging indigo blue dyed cloth :—

No. 105.—Yellow Discharge.

40 parts chrysophenine (Bayer & Co.).
240 ,, 8 ozs. gum tragacanth.
70 ,, wheat starch.
280 ,, water. Boil, and when cool, add
230 ,, red prussiate of potash.
140 ,, carbonate of magnesia.

No. 106.—Orange Discharge.

40 parts Congo orange G.
240 ,, gum tragacanth (8 ozs.).
70 ,, wheat starch.
280 ,, water. Boil, and when cool, add
230 ,, red prussiate of potash.
140 ,, carbonate of magnesia.

No. 107.—Red Discharge.

40 parts brilliant geranine B.
240 ,, gum tragacanth (8 ozs.).
70 ,, wheat starch.
370 ,, water. Boil, and when cool, add
180 ,, red prussiate of potash.
100 ,, carbonate of magnesia.

No. 108.—White Discharge.

240 parts gum tragacanth (8 ozs.).
70 ,, wheat starch.
410 ,, water. Boil, and when cool, add
180 ,, red prussiate of potash.
100 ,, carbonate of magnesia.

Print the above four colours with brush furnisher; steam for fifteen minutes without pressure; wash, and dry. The carbonate of magnesia paste is prepared by precipitation of 250 parts of sulphate of magnesia with 100 parts of Solvay soda dissolved in a good quantity of water, pouring off several times, filtering, and allowing to drain.

No. 109.—Yellow.

Extract paste,	8 gallons.
Diamond flavine G (Bayer & Co.),	1 gallon.
Acetate of chrome, 32° Tw.,	1 quart.
Acetate of alumina, 16° Tw.,	1 ,,
Acetate of lime, 24° Tw.,	1 ,,

No. 110.—Cutch Shade.

Extract paste,	8 gallons.
Alizarine SX, 20 per cent. (Bayer & Co.),	½ gallon.
Diamond flavine G, ,,	1 quart.
Acetate of chrome, 32° Tw.,	1 ,,
Acetate of alumina, 16° Tw.,	1 ,,
Acetate of lime, 24° Tw.,	1 ,,

No. 111.—Claret Shade.

928 parts extract paste.
28 ,, alizarine Bordeaux (Bayer & Co.).
24 ,, tartrate of alumina, 18° Tw.
16 ,, sulphocyanide of lime, 23° Tw.
4 ,, oxalate of tin, 25° Tw.

No. 112.—Plum Shade.

920 parts extract paste.
40 ,, alizarine Bordeaux B P (Bayer & Co.).
40 ,, acetate of chrome, 32° Tw.

No. 113.—Slate Shade.

893 parts extract paste.
3 ,, alizarine Bordeaux B P.
84 ,, ,, cyanine black G.
14 ,, acetate of chrome, 32° Tw.
6 ,, ,, lime, 24° Tw.

No. 114.—Tobacco-Brown Shade.

842 parts extract paste.
13 ,, alizarine Bordeaux B B.
17 ,, ,, orange R.
67 ,, ,, yellow G G (Bayer & Co.).
61 ,, acetate of chrome, 32° Tw.

No. 115.—Olive Shade.

819 parts extract paste.
13 ,, alizarine cyanine 3 R (Bayer & Co.).
100 ,, ,, yellow G G.
68 ,, acetate of chrome, 32° Tw.

No. 116.—Extract Black.

816 parts extract paste.
54 ,, alizarine Bordeaux B P.
50 ,, yellow G G.
80 ,, acetate of chrome, 32° Tw.

These last eight colours are to be printed on oiled cloth, steamed for one hour at 7 lbs. pressure, malted, and soaped.

CHAPTER V.—THICKENERS.

Thickening Materials Employed in the Printing of Calico.—Under the name of thickeners are understood such preparations as are added along with the colouring matters in order to give them the necessary amount of consistency to allow them to be printed on the required parts in order to produce the patterns without being liable to run or pass beyond their proper limit. The part played by the thickening is simply a mechanical one and has nothing to do with the fixing of the colours; there is, however, one exception to this in the case of albuminous substances, which act as fixers of the colours as well as thickeners. The thickening substances are generally some varieties of the gums or amylaceous matter so plentifully found in the vegetable kingdom, such as starch and its derivative dextrin, and the different kinds of gum, such as gum arabic, senegal, tragacanth, &c. They belong to the class of carbohydrates having the same empirical formula as cellulose.

Amylum or Starch, $C_6H_{10}O_5$, is found very largely spread in nature, being the principal constituent of some seeds, as for instance in the case of cereals; it is also found in the roots, stems, and fruits of many plants. Starch is found in the form of minute granules which, although possessing the same chemical composition, still show a great variety in their characteristics, according to the plants from which they are derived, especially on account of their sizes and shapes when viewed under the microscope, Figs. 17 to 22; the different starches

Fig. 17.—Tapioca starch.

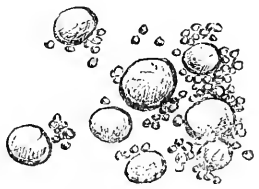


Fig. 18.—Wheat starch.

can readily be distinguished from each other in this way. Starch is a white substance insoluble in cold water, but possessing the peculiarity, when treated with boiling water, of swelling and forming a kind of gelatinous mass, the so-called starch paste, a property

for which it is utilised in practice, since by this process of boiling, the starch granules largely increase in size, and absorb at the same time a large quantity of water, and if the amount of water and starch have been taken in the right proportion, all the water is taken up and a jelly-like mass is formed, from which the water cannot be separated by mechanical means, not even by straining it through cloth. To this valuable property of starch granules is due

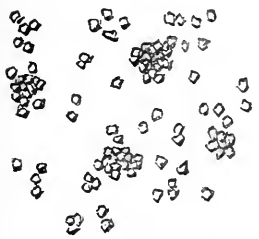


Fig. 19.—Rice starch.

Fig. 20.—Potato starch.

the employment of starch in calico-printing, since by being capable of absorbing solutions of mordants and colours, and keeping pigments in suspension, it enables printers to obtain mixtures capable of being properly printed on cotton. A very characteristic reaction of starch is that, when boiled with water, it gives a blue colour when treated with a solution of iodine in iodide of potassium.

Fig. 21.—Maize starch.

Fig. 22.—Sago starch.

Wheat Starch is by far the best thickening for calico-printing, and is the thickening material most employed for the preparation of colours to be printed on the roller printing machine. Good wheat starch should not contain more than 15 per cent. of moisture nor more than a $\frac{1}{2}$ per cent. of mineral matter, and should be perfectly free from grit. The admixture of wheat starch with potato or other cheaper starches is best detected under the microscope.

Maize Starch is sometimes used as a thickening for indigo-printing by the glucose process, as it stands the strong caustic soda very well.

Dextrin (known as British gum, gum substitute, &c.) is prepared from starch by a process which alters the properties of the starch without changing the chemical composition. There are several methods for changing starch into dextrin, such as exposing it to a dry heat of about 200° C. The method most generally adopted is that proposed by Payen, which consists of treating 400 parts of starch with 1 part of nitric acid and enough water to make into a stiff paste, which is dried and then exposed to a temperature of 200° C. The product thus obtained is lighter coloured than that produced by the first method; hence we have light and dark British gums.

Dextrin is soluble in water, but the various samples differ very much in their thickening power, some requiring as much as 8 or 10 lbs. to the gallon of water, while other samples will thicken with 2 or 3 lbs. Those samples of dextrin which thicken with 2 or 3 lbs. per gallon contain much unconverted starch; while those which require a very large amount, say 12 or 14 lbs. per gallon have been acted upon too much and changed into glucose. For printing purposes dextrin is best when it will thicken with about 6 lbs. per gallon. Colours thickened with dextrin penetrate less deeply into the fibre than those printed with starch thickening; hence after washing the dextrin colours are found to be lighter in shade.

Natural Gums (Arabic, Senegal, Indian gums, &c.).—They are not so largely used now as formerly. As found in commerce they differ very considerably both in price and quality. The best Arabic and Senegal gums are readily soluble in water, producing a clear solution, leaving but a small amount of insoluble residue, consisting of dirt, wood, &c. The Indian and other inferior gums are only partially soluble in water; even after long boiling only a semi-solution is obtained, which, on cooling, becomes "ropey" like a cold solution of soap. 2 lbs. of Indian gum at, say, 4d. per lb. will give a thicker solution than 5 lbs. of Arabic gum at 10d. per lb.; still the latter is preferable for some kinds of work. Gum tragacanth, commonly called "gum dragon," is a very useful, though somewhat expensive, thickening agent. It is the most powerful thickener used by the calico-printer, for if well boiled it gives a good thickening with $\frac{1}{2}$ lb. per gallon.

Albuminoid Thickeners.—The best, and in many print works the only, thickener of this class now in use is:—

Blood Albumen.—This substance is the dried serum of the blood of animals. The quality of this preparation has been much improved lately; in fact, so much so that but few printers will go to the expense of egg albumen, except for very special colours. Blood albumen as usually found in commerce is a dry thin scaley substance of a brownish colour. Lately a much improved brand of blood albumen has been placed on the market; it is in the liquid state and almost colourless; it is very cheap, and will keep for a long time as it contains an

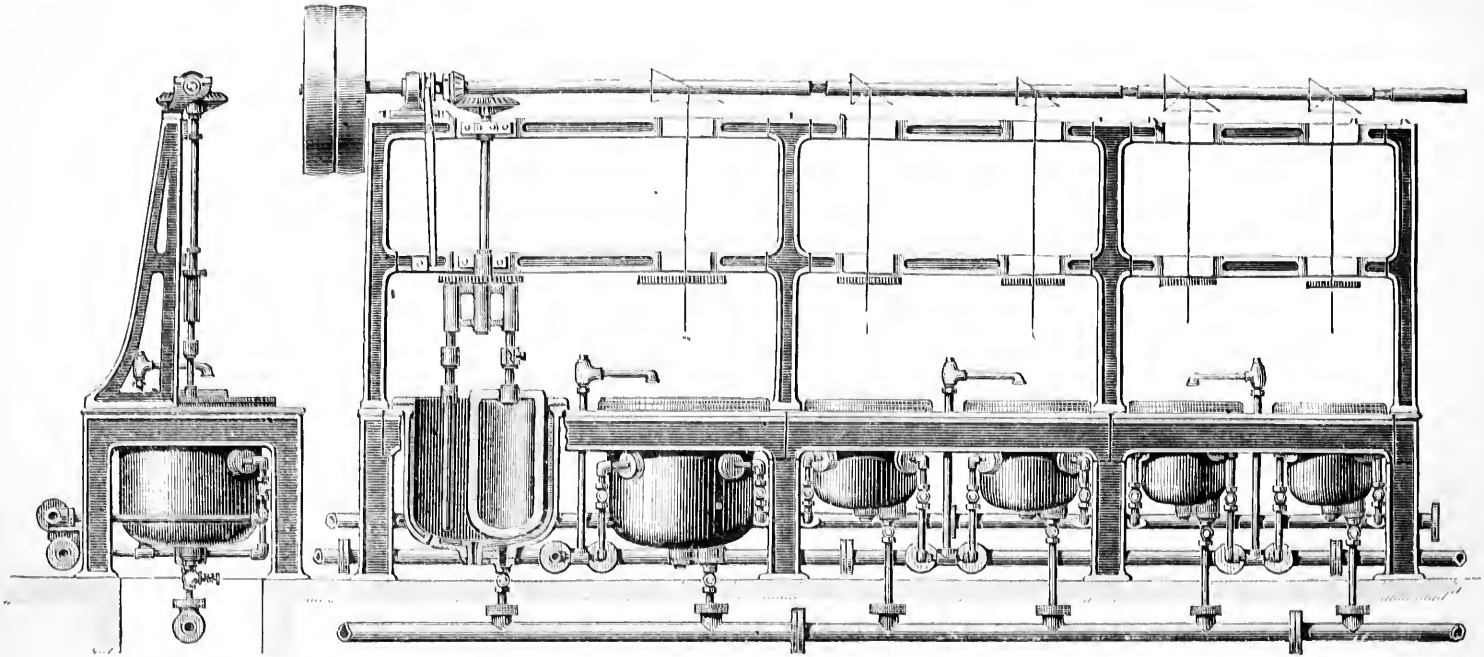


Fig. 23.—Double cased copper colour pans, with mechanical agitators, swing arm water-tap for pan, steam taps to inlet and outlet for steam between the casings; also water-taps to inlet and outlet between the casing for cooling the colours quickly.

antiseptic which, without injuring the albumen, preserves it from decomposition. Albumen should not be heated above 50° C. before printing, as it coagulates at 72° C.

The following table shows the amount of each of the thickeners in general use required to make 1 gallon of thickening for the average class of work, also the approximate cost per gallon of each of these thickenings :—

Wheat starch,	1¼ lbs.		3d.
Maize starch,	1 ,,		2d.
Light dextrin,	6 ,,	1s.	3d.
Gum Senegal,	5 ,,	3s.	9d.
Gum tragacanth,	¼ ,,	1s.	
Blood albumen	5 ,,	2s.	

Preparation of Thickeners.—For the purpose of dissolving thickeners, and also for the preparation of the printing colours, special vessels called "colour pans" (Fig. 23) are employed: these "colour pans" are double-cased copper vessels heated by steam, which is admitted between the pan and its outer casing. There are arrangements for admitting cold water between the pan and its outer casing, in order that the colour when sufficiently boiled may be quickly cooled. Water is also supplied to the pan itself by means of a swing-arm tap, and the entire pan is made to revolve on pivots, so as to be the more easily emptied and cleaned. During the whole of the time that the ingredients of a colour are being boiled, they should be constantly stirred, and this operation is in many cases continued until the mixture is cold. For this purpose the pans are provided with mechanical stirrers. These pans vary in size from 4 to 36 gallons. To make a thickening of wheat or maize starch, the starch is first mixed with the cold water and about 1 quart of olive oil to every 10 gallons. It is then raised to the boil and kept boiling for half an hour, stirring all the time in order to produce a smooth paste. Dextrin and gum Senegal are simply agitated with hot water until dissolved. Albumen is dissolved by agitation in water heated to not above 50° C. Gum tragacanth should be steeped in warm water for twenty-four hours; then boiled for six hours in the colour pan.

Straining.—A very important operation in colour mixing is straining, the object of which is not only to remove any lumps or grit from the colour, but also to effect a more thorough mixing, and to give more homogeneity and softness to the mass. Many attempts have been made to devise apparatus for straining by mechanical means, and where large quantities of the same colour are made these mechanical contrivances are fairly successful. But in works where a great variety of colours are required, the old laborious method of forcing the colours by hand through straining cloths is still employed. If the colours have to be strained by hand they should be first sent

through a coarse cloth, and then through one or more finer cloths. Very fine grit cannot be removed from thick colour by straining, as the pressure necessary to send the colour through the cloth will also force the grit through; it is, therefore, necessary to be very careful when making up a colour to see that no substance containing fine grit is used. The grit can easily be removed from liquids by allowing the liquid to run slowly through a fine cloth.

CHAPTER VI.—NATURAL ORGANIC COLOURING MATTERS.

Logwood (Campeachywood).—This is the heart-wood of a tree, a native of South America and the West Indies, and known botanically as *Hæmatoxylon campechianum*. This dyewood is generally found in commerce in the form of logs, hence its name, but is supplied to customers either rasped or chipped, or in fine powder, or as extract. The colouring matter contained in the wood is found as a glucoside. The ground wood is moistened with water, and undergoes a species of fermentation, in order to decompose the glucoside, when *hæmatoxylin* is formed, and this, by oxidation, is converted into *hæmatein*, the colouring principle of logwood—

$$\underset{\text{Hæmatoxylin.}}{C_{16}H_{14}O_6} + O = \underset{\text{Hæmatein.}}{C_{16}H_{12}O_6} + H_2O.$$

Hæmatein is a polygenetic colouring matter, as it forms differently coloured lakes with different metallic oxides.

With alumina it gives purple.
With oxide of copper it gives indigo blue.
With ferrous oxide it gives bluish-black.
With ferric oxide it gives brownish-black.
With chromic oxide it gives black.

Logwood and its commercial extract, which is a syrupy liquid of 48° Tw., are largely used for dyeing, and in the latter form is much used for printing, principally for the production of blacks, dark blues, drabs, greys, browns, and olives. A peculiar reaction of the colouring matter of logwood is that it turns red when treated with dilute acid. This reaction is very often utilised as a test for dyed goods which are supposed to be dyed or topped with logwood, by placing a small bit in water acidulated with sulphuric or hydrochloric acid; if the piece contains logwood, it will be shown at once by the red colouration it imparts to the dilute acid. The testing of the commercial value of logwood (as of all other natural organic colouring matters) is best effected by practical trials of dyeing and printing.

RED WOODS.

These are divided into two classes:—

1st. Those, the colouring matter of which is easily soluble in water, such as peachwood, Brazil wood, sapan, Lima wood, &c.

2nd. Those possessing the colouring matter not readily soluble in water, such as barwood, camwood, &c.

The red woods have sunk considerably in importance since the introduction of coal-tar colours.

Red woods with soluble colouring matter belong to the genus *Cæsalpinia*, and seem to contain the same colouring principle. The Brazil, Lima, and peachwood are produced in South and Central America, while sapan is brought into commerce from India, Japan, and China.

The colouring matter is found in the wood in the form of glucoside, which, when decomposed, produces a sugar, and a product called *brasilin*, $C_{22}H_{20}O_7$.

The red dyewoods are not largely used as self colours, but principally in combination with other dyestuffs for the production of compound shades, both in dyeing and in calico-printing (especially in the steam styles), when they are generally connected with mordants, and a certain amount of chlorate; with alumina mordants bluish-reds are produced; with iron and alumina, browns; with chrome, brown up to chocolate shades. The commercial extracts generally show 40° to 50° Tw.

They are principally employed for the preparation of red lakes, for paper staining, painting, &c.

Of the other class of red woods, barwood and camwood are now used in diminishing quantity in cotton dyeing, but never in direct printing. Barwood was at one time used, and is yet to a small extent, for the production of colours on cotton cloth, which imitate, pretty well, the old Turkey-reds. Barwood comes from the tree *Baphia nitida*, growing in Sierra Leone. Red sanders or santal wood is yielded by the small tree *Pterocarpus santalinus*, a native of India, and contains the colouring matter *Santalin*.

YELLOW DYESTUFFS.

Quercitron Bark.—This is the bark of a species of oak, *Quercus tinctoria*, growing abundantly in some parts of the United States, particularly Pennsylvania. This colouring matter is also found in the form of a glucoside called *Quercitrin*, which can be split up into a kind of sugar, and *Quercetin*, $C_{27}H_{28}O_{12}$, which is the colouring principle. Quercitron or bark extract, as found in commerce, is a thick syrupy liquid much used by calico-printers for the production of browns, olives, and many other shades; it is especially useful, in combination with logwood, &c., for the production of complex shades.

Flavine is a fine dry powder obtained from quercitron bark by a purifying process; hence, flavine is much stronger and yields purer shades than the bark, but as it is also much dearer it is not largely used.

Persian Berries.—These are the fruit of the *Rhamnus infectoria* growing in southern France and the Levant, also of the *Rhamnus amygdalinus* growing in Persia, the latter being the most valuable. The colouring matter of Persian berries is also contained in the form of a glucoside, which by splitting up yields *Rhamnetin* ($C_{12}H_{10}O_5$); this substance is very similar to quercetin. The extract of Persian berries, a liquid standing about 48° Tw., is very largely used by calico-printers. It gives a very bright yellow with alumina mordant, but this colour, like all vegetable yellows with alumina, is rather loose to soap and water. With stannous oxide Persian berries give a very bright orange, but this, unfortunately, does not stand light very well. With chromic oxide as the mordant, Persian berries give a very good bronze, or in more dilute solutions old gold shades, which are very fast, both to soaping and light. In combination with alizarine and alizarine green and chrome mordant, very good and fast browns and olives are produced.

Old Fustic.—This is not an important substance to the printer, but dyers still use it in some quantity, especially in combination with logwood for dyeing blacks. It is the wood of the *Morus tinctoria*, which comes from South America and the West Indies. Like logwood, it is met with in the form of logs, chips, powder, and extract. The colouring matter consists of two substances—*Moritannic acid* ($C_{13}H_{16}O_6$) and *Morin* ($C_{12}H_8O_5$). The yellows produced with this dyestuff are neither very bright nor fast.

Safflower, Saffron, Turmeric, Annatto, and many other natural but fugitive vegetable dyes have almost entirely been superseded by the cheaper, more brilliant, and more permanent coal-tar colours.

INDIGO.

This most important of natural dyestuffs is obtained from a genus of plants called *Indigofera*, which grow in India, the West Indies, South America, Africa, &c. Like many other vegetable dyestuffs, the colouring matter is not found ready formed in the plant, but is contained in what is called a glucoside, by Schunck named *Indican*, and this glucoside by fermentation is split up into two substances, as shown by the following equation:—

$$\underset{\textit{Indican.}}{C_{52}H_{62}N_2O_{34}} + 4H_2O = \underset{\textit{Indigotin.}}{C_{16}H_{10}N_2O_2} + \underset{\textit{Indiglucin.}}{6C_6H_{10}O_6}.$$

The colouring matter is contained principally in the leaves, and for the production of indigo the leaves, together with the young branches of the plants, are steeped in water contained in tanks until fermentation sets in. The clear yellow liquid is then drawn off into lower tanks, where it is strongly agitated, so as to bring the liquid into contact with air; the liquid is then allowed to rest, when the indigotin, which has been formed, settles to the bottom of the tank. The blue preci-

pitate is removed from the tanks into caldrons and boiled, in order to prevent any further fermentation, which would destroy the indigotin. After filtering and pressing, the cakes of indigo are then dried, packed in wooden boxes, and so sent into the market. The cakes of indigo, produced as above, do not consist entirely of indigotin, but contain from 25 to 75 per cent. of this colouring matter, an average quantity being about 50 per cent. There is generally present a small quantity of a reddish-colouring matter, which is a modification of indigotin called *indigo rubin*. Indigo rubin possesses similar properties to indigotin, except that it is soluble in alcohol, while blue indigotin is not. A good sample of indigo should not contain more than 5 per cent. of moisture, nor more than 10 per cent. of mineral matter, but inferior samples contain as much as 50 per cent. or even more of the latter. There are many methods recommended for the estimation of indigotin in commercial samples of indigo, but although some of the chemical methods are useful, principally as comparative tests, only practical tests by dyeing are thoroughly reliable. Even these, if not carefully conducted, are liable to error. The following method of estimating indigotin has been recommended by Mr. C. Rawson :—

One gramme of finely-powdered indigo is ground into a thin paste with water, and introduced into a flask with 500 to 600 c.c. of lime water. The flask is furnished with an indiarubber stopper, which has four perforations, in one of which is inserted a syphon closed by a pinch-cock, and in another is fixed a funnel provided with a stop-cock ; the other two apertures serve for the entrance and exit of a current of coal gas. The flask is connected with a supply of coal gas, and the contents heated to about 80° C.; 100 to 150 c.c. of a solution of sodium hyposulphite are now introduced by means of a funnel, and the mixture, which in a few minutes takes a yellow tint, is kept near the boiling point for half an hour. After allowing the insoluble matters in the flask to subside, 500 c.c. are syphoned off, and the remaining liquid accurately measured. The 500 c.c. are poured into a conical flask, and by means of an aspirator a current of air is drawn through the liquid for about twenty minutes. The excess of hyposulphite is thus oxidised to sulphite, and the indigo white to indigo blue. When hydrochloric acid is added to sodium hyposulphite, a copious precipitate of sulphur occurs, but after oxidising the liquid by a current of air, the solution remains perfectly clear on the addition of an acid. An excess of hydrochloric acid is, therefore, added in order to dissolve any carbonate of lime which the precipitate may contain. The precipitate is collected upon a weighed filter, thoroughly washed with hot water, dried at 100°, and weighed. The weight thus obtained is indigotin and indigo-red. If it is desirable to determine the amount of each of these constituents, the filter with its contents is placed in an extraction apparatus, and the indigo-red dissolved out by means of alcohol.

TABLE SHOWING THE PERCENTAGE OF INDIGOTIN IN VARIOUS CLASSES OF INDIGOS BY THE EMPLOYMENT OF DIFFERENT METHODS OF ANALYSIS.

METHOD.	I. JAVA.			II. BENGAL *a*.			III. BENGAL *b*.			IV. OUDE.			V. KURPAH.			VI. MADRAS.		
	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.	Mean.
1. Permanganate (direct), .	76·32	76·05	76·18	66·76	66·68	66·71	62·85	62·32	62·66	50·22	49·86	50·04	47·15	47·15	47·15	39·92	39·30	39·50
2. Permanganate (after precipitation by sodium chloride), . . .	73·82	73·27	73·55	...	...	63·50	57·74	57·30	57·50	...	...	44·90	43·30	42·90	43·10	...	...	37·40
3. Hyposulphite (volumetric), . . .	68·92	68·05	68·78	59·52	58·86	59·26	55·84	55·21	55·66	43·28	43·08	43·18	42·72	42·32	42·52	37·35	36·56	36·80
4. Sublimation, . . .	61·03	60·69	60·84	57·95	57·12	57·50	50·50	48·22	49·36	41·96	41·25	41·60	42·37	41·48	41·92	40·42	38·52	39·56
5. Reduction (by ferrous-sulphate and sodium hydrate), . . .	68·50	67·82	68·24	59·43	58·12	58·84	56·03	53·59	54·34	...	...	44·50	41·75	40·88	41·50	34·95	33·88	34·50
6. Reduction:— (Hyposulphite and lime) Indigotin, . . .	69·25	68·65	68·97	59·35	58·89	59·12	56·64	55·92	56·20	43·65	42·99	43·42	42·79	42·15	42·68	35·42	34·98	35·21
Indigo-red, . . .	4·50	4·01	4·23	3·84	3·24	3·50	3·00	2·60	2·80	3·93	3·42	3·65	2·52	2·25	2·45	4·12	3·75	3·98
Percentage of water, . .	...	...	2·99	5·28	5·15	5·22	6·25	6·10	6·17	...	...	7·50	...	...	8·05	5·80	5·62	5·71
,, ash, . .	...	...	1·99	...	...	3·91	...	...	4·86	...	...	8·21	25·85	25·62	25·72	33·75	33·50	33·62

Example.—One gramme of indigo is reduced by a mixture of sodium hyposulphite and lime water. The liquid measured 935 c.c. 500 c.c. are oxidised, and treated as above described. Weight of precipitate = ·243;

$$\therefore \quad \frac{\cdot 243 \times 935 \times 100}{500 \times 1} = 45\cdot 44 \text{ per cent. indigotin and indigo-red.}$$

The filter is placed in the extraction apparatus, and the red dissolved by means of alcohol. The alcohol solution is evaporated to dryness, dried at 100°, and weighed. Weight of extract = ·015. From this amount 1 milligramme is subtracted, in order to allow for the slight solubility of indigotin in alcohol.

$$\therefore \quad \frac{\cdot 0135 \times 100 \times 935}{500} = 2\cdot 52 \text{ per cent. indigo-red.}$$

Indigotin (by difference) = 42·92 per cent.

A very quick and practical method of testing the value of indigo is as follows :—Weigh off 1 gramme of the finely powdered sample, and put into a litre flask, avoiding any loss. Add 25 c.c of a normal solution of sodic hydrate (40 grammes per litre) and 10 c.c. of a saturated solution of hyposulphite of soda, then fill to the stopper with boiling water. If the flask be laid on its side and rolled over occasionally, it will be found that all the indigo will be dissolved in less than fifteen minutes. The contents of the flask is then emptied into a stone jar of about the capacity of a litre; the solution of indigo is allowed to settle in the jar for half an hour in order to cool and become clear. Now, take a strip of calico 8 inches by 2 inches, and holding the calico by one end, let about 5 inches of the other end dip into the jar of indigo and leave it there one minute; now withdraw the calico and hang up to dry without allowing it to crease or touch anything. Of course with this small strip of calico we shall not remove all the indigo from the solution, but it will be dyed to a shade the depth of which will depend upon the quality of the indigo under examination. If 1 gramme of pure indigotin be taken and treated as described above, it will be found to dye the strip of cloth a rather darker shade than can be got from any sample of commercial indigo. But if we take respectively $\frac{5}{10}$, $\frac{6}{10}$, $\frac{4}{10}$, and $\frac{2}{10}$ gramme of indigotin and treat in the same way, we shall produce standard shades, against which we can compare the samples we want to test. In this way, using 6 flasks, jars, &c, a man can test 20 to 30 samples in one day. The hyposulphite for the above must be freshly prepared, by shaking up in a stoppered bottle 1 pint of bisulphite of soda with 2 oz. of zinc powder for five minutes, then allowing it to settle and using the clear solution.

Indigotin is insoluble in all ordinary solvents, and, therefore, cannot be used as a dye until it has undergone some chemical change. The best substance known for bringing about this change is nascent hydrogen, which, by combining with the indigotin, converts it into what is called indigo-white.

$$\underset{\text{Indigotin.}}{C_{16}H_{10}N_2O_2} + H_2 = \underset{\text{Indigo-white.}}{C_{16}H_{12}N_2O_2}.$$

When the cotton is immersed in a solution of indigo-white, and then exposed to the air, the oxygen of the air combines with hydrogen, and removing it from the indigo-white, reconverts that substance into indigotin, which thus becomes fixed on the cotton.

There are various ways of producing nascent hydrogen—

1st. By fermentation of organic matter. This was the old method of producing indigo-white, or reducing the indigo, as it was called.

2nd. By some metallic hydrate, as ferrous hydrate, which, by decomposing water, liberates nascent hydrogen, thus—

$$2FeH_2O_2 + 2OH_2 = Fe_2H_6O_6 + H_2.$$

The ferrous hydrate is formed when copperas and lime are mixed with water, as in the copperas vat.

3rd. By the action of metallic zinc on caustic soda or lime and water, thus—

$$Zn + 2NaHO + 2H_2O = ZnNa_2H_4O_4 + H_2.$$

4th. By the action of hyposulphite of soda on water, thus—

$$Na_2OSO + H_2O = Na_2OSO_2 + H_2.$$

The above are the usual methods for reducing indigo, or, as it is called, "setting the blue vat." There are many ways of producing nascent hydrogen from acids; but these are not available, as the "blue vat" must be a slightly alkaline liquid in order to keep the indigo-white in solution. Indigo is destroyed by nascent oxygen by being converted into isatin, thus—

$$\underset{\text{Indigotin.}}{C_{16}H_{10}N_2O_2} + O_2 = \underset{\text{Isatin.}}{C_{16}H_{10}N_2O_4}.$$

This reaction is taken advantage of in the production of a pattern in discharge by printing upon indigo-dyed cloth (see p. 45).

It is easy to distinguish indigo from all other colouring matters by the following tests:—

1st. Dilute sulphuric acid has no action.

2nd. Caustic soda solution has no action.

3rd. Strong nitric or chromic acids destroy the indigo, which cannot be recovered.

4th. Treated with a solution of hyposulphite of soda (out of contact with air), the blue is discharged; but if the solution be shaken up with air, it becomes blue again.

5th. Heated in a small porcelain dish, violet vapours are given off.

MADDER.

This is the root of *Rubia tinctorium* and *Rubia peregrina*, plants which grow in Europe. The best madder is grown in the Levant, and is known by the name of alizari. But madder, like most other vegetable dyestuffs, has been driven out of the market by the cheaper and handier coal-tar colour, alizarine, so that madder has become a very unimportant substance to the calico-printer and dyer.

CHAPTER VII.—TANNIN MATTERS.

Under this head are included a great variety of vegetable products, the active principle of which is tannin or tannic acid. They include sumach, gall-nuts, myrobolans, divi-divi, barks, kino, hemlock, valonia, catechu, and many others. The most valuable of these are

Gall-nuts, an excrescence formed by the puncture of the gall-fly upon the twigs of certain species of oaks. Several varieties of gall-nuts are found in commerce, among which the principal are Aleppo or Turkish galls, China galls, French galls, &c. They vary considerably in price and quality, according to the proportion of tannic acid contained in them. The Aleppo galls are the best, containing sometimes as much as 77 per cent. of tannic acid, then come the China galls, which are nearly as good as the Aleppo. The French galls are much inferior, containing only 20 to 30 per cent. of tannic acid. Gall-nuts were formerly much used as a mordant in dyeing, and are used for the preparation of gall extract; but the principal use of gall-nuts is for the preparation of pure tannic acid.

Tannic acid, $C_{14}H_{10}O_9$, is produced on a large scale, and is much used for dyeing, and especially for calico-printing, when delicate shades are required. It is sold either as a powder or as needle-shaped crystals. Tannic acid forms insoluble lakes with the basic coal-tar colouring matters, and insoluble tannates with many metallic oxides; but it is in the form of the double tannate of the colour base and a metallic oxide that the fastest and best colours are produced; hence the necessity for treating with a bath of tin or antimony salts cloth which has been dyed or printed with tannin and a basic colouring matter.

Sumach is the dried and ground leaves and young twigs of different plants of the family of *Terebinthaceæ*, genus *Rhus;* the most important is the Sicily sumach (*Rhus coriaria*), but there are many other varieties grown in Europe and America. The best sumach contains 20 per cent. of tannic acid, and is much liked by fancy-shade dyers on account of its containing only a small amount of colouring matter.

Myrobolans contain more tannic acid than sumach, and are preferred for dyeing a full jet black. The commercial article is the dried and crushed pulp of the fruit of *Terminalia chebula*, which grows in India.

Valonia, Divi, Hemlock, Oak bark, &c., although they contain a comparatively large quantity of tannin, are not largely used for

dyeing and printing, but are extensively used in the manufacture of leather.

The chemical methods for determining the proportion of tannic acid in these wares are somewhat difficult to carry out, but the method which is generally employed is to dye a fent of calico which has been printed all over, or in stripes, with a standard iron mordant, and compare the depth of shade against that obtained by a similar trial with pure tannic acid. Decoctions of tannin matters, if kept for a long time, undergo a fermentation and split up into gallic acid and glucose, which do not act as mordants for the basic colours, and are, therefore, useless.

CHAPTER VIII.—OILS—SOAPS—SOLVENTS.

OILS.—Colour Oil.—Paste colours for printing are much better if made with the addition of a small quantity of oil (from 1 in 32 to 1 in 16); the colours thus made are better to print with, and keep much better than when made without oil; they are also much better to strain, especially after they have been kept a few days, and they froth less in working. The best oil for this purpose is olive oil, though many other cheaper oils are used; but olive oil imparts the least objectionable odour to the printed goods, some oils being very bad in that respect, especially after the goods have been kept in stock for some time. Olive oil consists of two fatty bodies, *trioleine*, $C_3H_5(OC_{18}H_{33}O)_3$, and *tripalmitin*, $C_3H_5(OC_{16}H_{31}O)_3$. A variety of olive oil, the Gallipoli, or emulsive oil, was formerly much used in the production of Turkey-reds. The Gallipoli oil is olive oil which has been extracted from unripe olives; it has been allowed to become rancid, and contains free oleic acid. It readily forms permanent emulsions with weak alkalies. The finest kinds of olive oil have a pale yellow colour with a tinge of green, are almost free from odour, and possess a mild and agreeable taste. Inferior qualities have a greenish-yellow or brownish-yellow colour, an unpleasant odour, and an acid taste. Owing to its superior commercial value, olive oil is very liable to adulteration—cottonseed, nut, poppy, rape, and other oils being used for the purpose.

Castor Oil is the fixed oil pressed from the seeds of the plant *Ricinus communis;* as found in commerce it is a colourless oil of high density and viscosity, having a faint odour and disagreeable taste. It consists of a mixture of solid fat—tripalmitin—with the glyceride of ricinoleic acid, $C_3H_5(OC_{18}H_{33}O_2)_3$. At one time it was only used in medicine, but it is now very largely used in the preparation of "oleine" or alizarine oil, an oil mordant largely used in alizarine dyeing and printing.

PREPARATION OF OLEINE OR ALIZARINE OIL.—Many dye and print works prepare their own oleine oil; the details of the method of preparation vary with each works, and are generally kept jealously secret, but the process is a very simple one, consisting in the main as follows:—To 100 parts of castor oil of good quality, add slowly 30 parts of sulphuric acid of 1·5 specific gravity, and leave the mixture over-night. It is best to make the mixture in a leaden vessel, pouring in the acid in a thin stream, and keeping the mixture stirred with a mechanical agitator; the temperature of the mixture should not rise

above 35° C. After standing over-night, the excess of sulphuric acid in the product is then removed by agitating (in a large wooden barrel) with a solution of common salt; after settling, the salt water is drawn off from the bottom of the cask, and the oily product which remains is mixed again with salt water, and after settling, the salt water is drawn off as before. After washing, the oleine is nearly neutralised with caustic soda, and finally completely neutralised with a solution of ammonia. The oleines of commerce are sold according to the amount of fatty acid they contain, which may vary from 25 to 75 per cent., the usual proportion being about 50 per cent. The product consists chiefly of sodium-sulpho-ricinoleate, $C_{18}H_{33}(NaSO_3)O_3$.

A good method of estimating the amount of sulpho-ricinoleic acid present in a sample of oleine oil, though perhaps not strictly accurate, consists in treating 50 c.c. of the sample with about 60 c.c. of water and 20 c.c. of sulphuric acid, 1·5 specific gravity. The operation is most conveniently conducted in a flask, the body of which holds 200 c.c., and the neck—which should be long, narrow, and graduated—an additional 50 c.c. 60 grammes of salt are then added, the contents of the flask well shaken up; and, lastly, the flask filled up to the top mark on the neck with water. After standing about one hour, the volume of fatty acid which rises into the neck of the flask can be read off. Another method is to heat 10 grammes of the sample in a porcelain dish on the water bath with sufficient dilute sulphuric acid to decompose it, adding 75 c.c. of a saturated solution of common salt and 25 grammes of wax. The sulpho-ricinoleic acid is insoluble in the brine, and therefore rises to the surface and combines with the melted wax. After cooling, the cake of wax is removed, dried as completely as possible on filter paper, carefully heated to remove the last trace of water, and weighed; the excess over 25 grammes gives the weight of fatty acid in 10 grammes of the sample.

SOAPS.—By the term soap is usually understood the various commercial products obtained by the action of alkalies on fatty oils. The soaps of commerce may be divided into two classes—hard and soft. Hard soaps are made with solid animal and vegetable fats, free oleic acid, and rosin, by treatment with caustic soda. They are the soda salts of the fatty and resin acids, the excess of alkali and glycerine having been separated. Soft soaps are made with fish oil or vegetable drying oils, by treatment with caustic potash, the excess of alkali and the glycerine being left in; hence soft soaps are generally more caustic than hard soaps. There are various methods by which soap is manufactured—the cold process; the boiling method, followed by salting out, &c. The so-called "cold process" consists in mixing the fat, previously melted at as low a temperature as possible, with just sufficient strong soda ley (at about the same temperature) to effect complete saponification. The process has the advantage of being simple, and is often employed for the preparation of the cheaper kinds of soap. But

the saponification is apt to be very incomplete, the product often containing both free alkali and unsaponified oil, besides which only the purest materials are available, as the whole of the glycerine and extraneous matters are retained in the final product. "Marine soap," so called from its valuable property of forming a lather with sea water, is made by boiling palm-nut or coco-nut oil with caustic soda ley of 1·163 specific gravity. The alkali is added gradually until the presence of a faint excess is indicated by the taste.

A good soap for the calico-printer and dyer must possess two important properties: it must be as neutral as possible, and thoroughly saponified; this second quality is of great importance, since two soaps may contain exactly the same amount of alkali, and yet one will not act as well as the other if it has not been well boiled or saponified, since in this case it will not consist entirely of the combination of the fatty acid with the alkali, but will contain also both undecomposed fat and soda. A good and sufficiently long boiling of the soap in manufacturing, and a good mixing when salting out, will give a good product, since any free alkali will be dissolved in the salt liquor along with the glycerine, and a second washing of the separated soap with hot salt water will, if well stirred, remove any excess of alkali still left in the product.

ASSAY AND ANALYSIS OF SOAPS.—A comparative assay of different soaps can be effected in a very simple manner by ascertaining what measure of a standard solution of the sample must be added to a given quantity of a standard hard water in order to obtain a persistent lather on shaking (see p. 127). One gramme of each sample to be tested should be dissolved in 100 c.c. of proof spirit. The test is made exactly as in determining the hardness of water, the soap solution being added to the standard hard water in small quantities at a time till a lather is obtained on shaking, which remains for at least five minutes; the smaller the quantity of soap solution required to produce a permanent lather, the better the sample of soap. The complete analysis of soap is a somewhat difficult and tedious operation, but a determination of the leading constituents will be sufficient for most purposes. Soaps for use in printing and dyeing should be tested for the proportions of water, total alkali, free caustic alkali, combined fatty acids, and unsaponified fats; and alkali in combination as soap.

Determination of Water.—The determination of water in soap is important. If the soap is a solid one a fairly representative sample should be reduced to fine shavings by scraping with a knife, 10 grammes is then exposed in a watch-glass for some time to a temperature of about 50° C., the heat being gradually raised to 100° C., and continued at that temperature as long as a loss of weight is observed. The soap should not be allowed to melt. The proportion of water in soap varies enormously; in some of the best kinds of curd

soap it does not exceed 16 or 20 per cent., while in inferior soaps it sometimes reaches as high as 40 or 50 per cent. To determine the amount of unsaponified fat, place the 10 grammes of dried soap in a plaited filter paper, and exhaust it with redistilled petroleum ether in a Soxhlet's fat extractor. The solution will contain the unsaponified fat, the amount of which may be ascertained by evaporating off the ether, drying the residue at 100° C., and weighing.

To Determine the amount of Fatty Acids combined as Soap.—Dissolve 10 grammes of the soap in hot water (using a beaker to contain the solution), add a known measure of standard sulphuric acid to the hot solution, using a moderate excess of the standard acid over that required to neutralise the alkali of the soap. While the solution is hot add 20 grammes of white beeswax, then allow it to become quite cold. The fatty acids become amalgamated with the wax, and on cooling, a firm coherent cake is formed, which may be at once rinsed, dried, and weighed; this weight less 20 grammes gives the *total amount* of fatty acids, and the amount of unsaponified fat previously determined deducted from this, gives the amount of fatty acids combined as soap; this latter in good soaps should be not less than 60 per cent., whilst the uncombined fatty acids should amount to very little, ·5 per cent., or nothing at all.

To Determine the Total Alkali.—Add a small quantity of methyl orange to the acid solution, from which the cake of separated fat and wax has been removed, and titrate with standard alkali. The difference between the free acid thus found and that previously added gives the equivalent of acid required to neutralise the total alkali of the soap, which should not amount to more than 9 per cent.

To Determine the Free Caustic Alkali.—Exhaust 10 grammes of the sample with 150 c.c. of absolute alcohol, by shaking in a stoppered bottle. *N.B.*—A good sample of soap will almost entirely dissolve, leaving only a very small amount of insoluble residue (about 1 per cent.). When the soap has dissolved, filter the solution, and add a few drops of a neutral alcoholic solution of phenolphthalein; if a pink colour is produced, titrate cautiously with a decinormal acid (1 c.c. = 0·004 caustic soda), the volume of which required corresponds to the free caustic alkali of the soap, and should not much exceed 1 part per thousand. If no pink colouration is produced on adding the phenolphthalein, the liquid should be titrated with decinormal caustic soda; the volume of this required gives the amount of free fatty acids, which again should be very little in a well-made soap.

To Determine the amount of Alkali existing in combination with Fatty Acids as Soap.—To the alcoholic solution, which has been rendered neutral to phenolphthalein, add a few drops of methyl-orange solution and titrate with standard acid. This gives the alkali combined as soap, and should be about 7 per cent. The number of c.c. of acid

required multiplied by ·04 = alkali (soda) in soap. A good soap should, therefore, consist of about from

20 to 30	per cent.	water,
60 ,, 70	,,	fatty and resin acids,
6 ,, 8	,,	soda as soap,
0·1	,,	free caustic soda,
Not more than 1	,,	matters insoluble in alcohol,

And little or no unsaponified fatty matters.

SOLVENTS.

Acetic acid, $HC_2H_3O_2$, is the most useful organic acid used in dyeing and printing, owing to its property of being a solvent of aniline dyes, as well as of metallic oxides and colour lakes; whilst at the same time it has no injurious action on the cotton fibre. Acetic acid should be nearly colourless, should give no turbidity when a solution of nitrate of barium or of nitrate of silver is added, and should leave no residue when evaporated to dryness. The strength of acetic acid (such as is suitable for dyeing and colour-making purposes) can easily be determined by titration with standard alkali, using phenolphthalein as the indicator. The commercial acetic acid generally has a strength of about 30 per cent. There is a very pure acid (containing upwards of 97 per cent.) called glacial acetic acid, but this is seldom employed in dyeing and printing, as it is too expensive for that purpose. There is also a crude acid called pyroligneous acid, but it contains too much colouring matter to allow of its being used for most purposes in dyeing and printing, though it is from this crude acid that most of the acetic acid of commerce is made.

Glycerine, $C_3H_5(OH)_3$, a bye-product in the manufacture of stearine candles, and also in the manufacture of soap, is used largely by some colour-makers who think it improves the printing qualities of the colours. It is also used as a solvent of "white arsenic" in the preparation of an arsenious mordant used for the fixing of basic aniline colours; but this way of fixing colours is very objectionable owing to the poisonous nature of the arsenic, and ought not to be tolerated. Glycerine is very liable to impurities and adulterants, especially that which is produced from soapmaker's waste. Distilled glycerine leaves only a very small amount of ash, 0·2 per cent., whilst crude glycerine may leave 10 per cent., or even more. Pure glycerine does not blacken when gradually mixed with its own volume of cold strong sulphuric acid; sugar and other impurities cause a marked darkening or even charring; pure dilute glycerine does not reduce Fehling's copper solution when heated with the reagent to 100° C. for a few minutes; but glucose, if present, will reduce the copper compound even before the boiling point is reached.

Acetin.—This solvent is used in printing colours containing some basic colouring matters, as indulins, &c., which are not soluble in water

or acetic acid. It is prepared by heating a mixture of 2 parts of glacial acetic acid and 1 part of glycerine for forty-eight hours at the boil, in an apparatus fitted with an inverted condenser.

Ethyl Tartrate.—This solvent of coal-tar colouring matters is an article of commerce, and is prepared by heating a mixture of finely-powdered tartaric acid and pure alcohol in the same kind of apparatus that acetin is made in; the mixture is boiled until the alcohol has combined with the tartaric acid.

CHAPTER IX.—ORGANIC ACIDS—SALTS.

ORGANIC ACIDS.

Citric Acid, $C_6H_5O_4(OH)_3 + H_2O$, is very largely used in calico-printing as a discharge or resist on alumina and iron mordants, in the madder styles. It occurs in a free state in the juice of many fruits, especially those of the genus *Citrus*, the lemon, lime, &c., from which it is extracted. The so-called "acid" used by printers for the above purpose is merely the concentrated juice of the lime and lemon fruit. This "acid" or lime juice contains many organic substances, but the citric acid is the only one of any use. Lime juice is usually bought and sold according to its specific gravity in Twaddel degrees; but this method of valuation is open to many frauds, for many substances may be added to increase the density or even the acidity of the juice, which are of no value to the printer. The following is a better method of finding the value of a sample of lime juice:—To 10 c.c. of the juice add 5 c.c. of rectified spirit free from acid, then add a small quantity of a solution of caustic potash, and stir the cold liquid in a test tube with a glass rod, rubbing the side of the tube with the glass rod for a few minutes; if any precipitate forms, tartaric acid is present and must be removed by filtration. If no precipitate forms (or if formed, after it has been removed), the contents of the test tube must be poured into a porcelain basin, rinsing the tube and rod with water, allowing all to pass into the basin without loss. The contents of the basin is now heated until it begins to boil; if the odour of pine apple is given off, acetic acid is present, and the evaporation should be continued until all the acetic ether has been evolved. The contents of the basin is next exactly neutralised with dilute pure caustic soda, using phenolphthalein as the indicator; now evaporate to dryness on a bath of glycerine, remove from the bath and carefully ignite at a low red heat to convert the citrates into carbonates. Treat the residue with water to dissolve the carbonates, add a quantity of peroxide of hydrogen (sufficient to convert any sulphides into sulphates), and boil. A known quantity of standard sulphuric acid (sufficient to more than neutralise the alkali) is then added, the liquid boiled and filtered, and the excess of sulphuric acid determined in the filtrate by standard alkali. The amount of sulphuric acid neutralised by the ash is equivalent to the total citric acid in the sample. Alkaline citrates will be included in the above estimate of citric acid, but this is only

just, since alkaline citrates are equally as effective for resisting mordants as is citric acid in the free state. Bisulphate of soda—the most common adulterant—will be ignored if the precaution is taken of adding hydrogen peroxide after ignition.

Tartaric Acid, $C_4H_4O_4(OH)_2$, is used in the preparation of some steam colours, and very largely in the discharge colours in the Turkey-red process. It is obtained from tartar, or argol, a deposit formed on the bottom and sides of the vessels in which wine is manufactured. It is a well-crystallised acid, generally of great purity. It is easily estimated by the usual method of titration with normal caustic soda, using phenolphthalein as indicator.

Oxalic Acid, $C_2O_2(OH)_2,2H_2O$.—This acid is used, together with sulphuric acid, in the indigo-blue discharge style; it is also used sometimes in steam colours, but it is very risky to do so as it reacts on cotton in steaming like a mineral acid, having a very destructive action. Oxalic acid is found in commerce in a very pure state, it can be easily estimated by titration with caustic soda in the usual way.

SALTS.

Stannous Chloride, $SnCl_2 + 2H_2O$, generally known as "tin crystals" or "tin salt," is largely used both in cotton dyeing and printing.

It is prepared by dissolving metallic tin previously feathered, in hydrochloric acid, the solution being afterwards concentrated to the crystallising point. It should contain from 50 to 52 per cent. of metallic tin. It is supplied by chemical manufacturers in a state of almost chemical purity. The dry tin salt should be clean, and should give a slippery feeling to the fingers, not wet nor yet too dry. When 2 ozs. are mixed with a gill of water it should dissolve to a clear solution, but when the same quantity is added to a gallon of water, the liquor ought to be milky looking; this test shows, in the first case, that the salt is acid enough, and, in the second, that it is not too acid. Stannous chloride is often sold in the liquid state under the names of muriate—standing about 60° Tw.—and double muriate of tin, standing about 120° Tw.; but the number of degrees Twaddel is no sure indication of the strength of the solution, since common salt or other chlorides, if added, would increase the density, and, consequently, either in the case of stannous chloride or tin solutions, it is best to estimate the amount of tin by volumetric analysis as follows:—Weigh off $\frac{1}{2}$ gramme of the tin salt or 2 grammes of tin solution and dissolve in about 50 cc. of water; add 2 grammes of pure hydrochloric acid and $\frac{1}{2}$ gramme of pure zinc foil, and boil till all the zinc is dissolved (this is to reduce any stannic salt to the stannous state); add Rochelle salt and bicarbonate of soda in excess (if enough of Rochelle salt is present the solution

will remain clear); starch liquor is then added and the solution is titrated with $\frac{N}{10}$ iodine till a blue colouration appears. 1 c.c. of the iodine solution = ·0059 gramme metallic tin.

Stannic Chloride, $SnCl_4$, is obtained by oxidation of the stannous salt by different methods; the purest salt is obtained when chlorine gas is passed into a solution of stannous chloride. But the cheapest method of oxidation is by means of chlorate of soda and hydrochloric acid, thus—

$$3SnCl_2 + 2\,aq. + NaClO_3 + 6HCl = 3SnCl_4 + NaCl + 5\,aq.$$

The proportions to be taken are, therefore—

675 parts of tin crystals.
648 ,, hydrochloric acid (33 per cent.).
106·5 ,, chlorate of soda.

The tin crystals and hydrochloric acid are first mixed together in a stoneware vessel, with about their own weight of boiling water, and then the chlorate of soda in small portions at a time; an excess of chlorate is shown by the evolution of chlorine gas. By this method of preparation the stannic chloride is mixed with a small amount of common salt, but for most purposes this will be no detriment to it.

Stannic Oxide, SnO_2, is produced when carbonate of soda is added to a solution of stannic chloride.

$$SnCl_4 + 2Na_2OCO_2 = SnO_2 + 4NaCl + 2CO_2.$$

The precipitated stannic oxide must be well washed by decantation to free it from common salt. This oxide is never used in dyeing and printing, but it is largely used for making stannic salts, which are much used for that purpose.

Stannate of Soda, Na_2OSnO_2, is simply stannic oxide dissolved in a solution of caustic soda, thus—

$$SnO_2 + 2NaHO = Na_2OSnO_2 + H_2O.$$

This salt has been very largely used as a preparation in the "steam styles," but is not nearly so much used now, since good steam colours can be produced upon the much less expensive oleine-oil preparation.

To prepare with stannate of soda, the goods are first taken through a solution of the stannate, 10° to 20° Tw., and afterwards through sulphuric acid at about 2° to 4° Tw., then well washed. The sulphuric acid combines with the soda and precipitates the stannic oxide on the fibre, thus—

$$Na_2OSnO_2 + H_2OSO_3 = Na_2OSO_3 + SnO_2 + H_2O.$$

Stannic Oxalate, $SnO_2(C_2O_3)_2$, and **Stannic Citrate,** $(SnO_2)_3(C_{12}H_{10}O_{11})_2$.—These are used in some steam colours; they are both prepared by dissolving stannic oxide in the acids; the oxide is not completely soluble, but the milky liquid is what is used.

Stannous Acetate, $SnO(C_4H_6O_3)$.—This salt is now largely used for producing discharge effects upon cloth dyed with benzopurpurine and other direct colours (stannous chloride when used for this purpose tenders the cloth). Stannous acetate is produced when a solution of stannous chloride is mixed with a solution of acetate of lead, thus—

$$SnCl_2 + PbO(C_4H_6O_3) = SnO(C_4H_6O_3) + PbCl_2.$$

Potassium Antimony Tartrate, $KSbOC_4H_4O_6$, commonly called tartar-emetic. This commercial product has been largely used for giving greater fastness to the tannates of the basic coal-tar colours. In its pure form, tartar-emetic is a clear crystallised salt containing 35·5 per cent. of metallic antimony; it is prepared by boiling in water a mixture of antimonious oxide and cream of tartar, and crystallising the salt. As the virtue of the tartar-emetic is due to the antimony alone, the expensive tartaric acid is now generally replaced by the much cheaper oxalic acid to form the

Potassium Antimony Oxalate, $K_3SbO_3(C_2O_3)_3 + 6$ aq., which contains about 20 per cent. of antimony. Although the oxalate contains a much smaller proportion of antimony than the tartrate, yet, as the selling price is in a still lower proportion, the oxalate is the cheaper salt of the two.

Antimony is best determined by iodine in an alkaline solution. 1 gramme of the antimony compound is dissolved in 20 c.c. of water, 20 c.c. of a saturated solution of Rochelle salt is added, also 20 c.c. of a saturated solution of bicarbonate of soda, together with a few drops of starch liquor. A decinormal solution of iodine is then run in from a burette till a blue colouration occurs. Each cubic centimetre of decinormal iodine required = ·0061 gramme of metallic antimony.

LEAD SALTS.

Acetate of Lead, $PbO(C_4H_6O_3) + 3$ aq., is a salt which has been very largely used both by dyers and printers. In commerce two qualities are distinguished, generally known as white and brown sugar of lead.

Lead Nitrate, $PbO(N_2O_5)$, is a white crystalline salt, which is sometimes used in place of acetate of lead. These lead salts are generally used for the production of chrome yellows, which are simply chromates of lead (pigment-yellow), thus—

$$PbO(N_2O_5) + Na_2OCrO_3 = PbOCrO_3 + Na_2O(N_2O_5).$$

The amount of lead in acetates and nitrate of lead may be estimated as follows:—Weigh off 2 grammes of the lead salt and dissolve in hot water, adding a drop or two of nitric acid if necessary, precipitate the lead as carbonate by adding excess of carbonate of soda, wash the precipitate well, and dissolve in a measured quantity of normal nitric acid; titrate for excess of nitric acid. Each cubic centimetre of normal

nitric acid required to dissolve the carbonate of lead = ·1035 gramme of metallic lead.

Bichromate of Soda, $Na_2Cr_2O_7$.—This salt has now come to be of very great importance since it has replaced the more expensive potassium salt. It is largely used by calico-printers as a source of chromic acid in the indigo-blue discharge style, also for the production of acetate of chrome now so largely used in the extract style. It is also largely used by dyers and printers in the production of chrome-lead yellows, chrome-iron buffs, catechu browns, and other raised colours in the chromed or raised style. Bichromate of soda is very deliquescent, readily attracting moisture from the atmosphere, and when exposed for a long time in damp places, it has been found to attract so much water as to form a solution, and leak out of the vessel containing it, but this can be easily avoided by keeping it in a dry room. When of good quality, it will be found an advantageous substitute for bichromate of potash; its greater solubility is in its favour. Bichrome should be thus tested for the amount of chromic acid:—Weigh off 5 grammes of the sample, dissolve in water and make up to 1 litre. Take off 20 c.c. of the solution, and mix with it 5 c.c. of hydrochloric acid and 10 c.c. of a 10 per cent. solution of potassium iodide. The mixture is allowed to stand about half an hour, and then the liberated iodine determined with decinormal hyposulphite and starch liquor. Each cubic centimetre of decinormal hyposulphite required = ·00438 gramme of $Na_2Cr_2O_7$.

Phosphate of Soda, $Na_2OHPO_3 + 12$ aq.—This is a very useful fixing agent for alumina and iron mordants, being far preferable to the poisonous arsenite of soda too often used. To estimate the amount of pure phosphate of soda in a given sample, the following solutions must be prepared:—

1st. *Decinormal Solution of Phosphate of Soda.*—Dissolve 11·93 grammes of pure dry phosphate of soda in water, and make up to 1 litre.

2nd. *Acid Solution of Sodic Acetate.*—Dissolve 100 grammes of sodic acetate in water, add 100 c.c. of strong acetic acid, and dilute to 1 litre.

3rd. *Decinormal Solution of Uranium Nitrate.*—Dissolve 18 grammes of uranium nitrate in water, and make up to 1 litre. Some finely-powdered yellow prussiate of potash will also be required. As the uranium nitrate cannot be depended on, the solution must be titrated to determine its strength, as follows:—Measure out 100 c.c. of the decinormal sodium phosphate into a beaker, add 5 c.c. of the acid solution of sodic acetate, heat in a water bath to about 80° C., then run into it the uranium solution from a burette, stirring with a thin glass rod; after about 90 c.c. have been run in, bring a drop of the mixture, on the point of the rod, upon the surface of a white plate, then, with a bit of platinum wire moistened with the breath, bring a

small particle of the powdered yellow prussiate into the middle of the drop on the white plate, and wait a moment to see if any brown stain, however faint, appears. Should this not occur, add cautiously more of the solution until the colouration is produced in fresh drops tested from time to time. Repeat the experiment with a fresh portion to be certain of the exact point, then read off the burette the number of cubic centimetres required. Suppose 96 c.c. of the uranium solution have been required to produce the colour with 100 c.c. of the phosphate solution, then every 96 c.c. of the uranium solution must be diluted to 100 c.c., or 960 made up to 1,000 c.c. The uranium solution will then be strictly decinormal. Any sample of sodium phosphate can now be tested by treating in exactly the same way as the pure sodium phosphate has been—*i.e.*, weigh off 11·93 grammes, and make up to 1 litre, take off 100 c.c., add 5 c.c. of acid sodium acetate, heat to 80° C., and titrate with the corrected decinormal nitrate of uranium, testing carefully towards the end for the appearance of the brown stain. Each cubic centimetre of uranium solution required = 1 per cent. of pure sodium phosphate in the sample.

Carbonate of Lime (Chalk), $CaOCO_2$.—This is a very useful dunging material; it prevents the dunging beck becoming acid by combining with any acid liberated from the cloth. The chalk for dunging purposes should be a finely-ground white powder, almost entirely soluble in pure nitric acid, from which solution it should give no brown precipitate on the addition of ammonium chloride and ammonia.

Acetate of Lime, $CaO(C_4H_6O_3)$.—This salt, which is much used in the preparation of extract colours for calico-printing, is best prepared on the works by neutralising acetic acid with chalk or lime; if properly prepared it will stand at 24° Tw.; it should give no precipitate on the addition of ammonium chloride and ammonia.

Alumina Salts have already been treated of under the heading "Mordants," but there is one thing more to be said about them—that is, they should always be tested for traces of iron. This is best done by padding a small bit of white cloth in a solution of yellow prussiate of potash, and then, without drying, dipping it into the red liquor or other solution of alumina salt to be tested; if a blue stain is produced on the cloth, then the alumina solution contains iron, and is not fit for use. The amount of alumina should also be estimated gravimetrically by adding ammonia in excess; boil well, filter off the precipitate, wash, dry, and carefully ignite and weigh as Al_2O_3, which, in good red liquors at 16° Tw., should be about 4 per cent., and very little or no precipitate should be given on adding a solution of barium chloride.

CHAPTER X.—MINERAL COLOURS OR PIGMENTS.

These are insoluble substances and, therefore, cannot be used as dyes, but they are fixed upon cotton cloth by means of albumen in the so-called pigment style of printing.

White Pigments.—The best of these is *oxide of zinc* (zinc white) which is used for producing a light pattern on coloured grounds; also for mixing with other pigments to give body to the printing colour.

Sulphate of Barium, $BaSO_4$, sometimes called permanent white, is occasionally used for the same purpose as zinc white, but it is very heavy and does not make up a good printing colour, nor has it the same covering power that oxide of zinc has.

China Clay (Silicate of Alumina) is largely used for weighting and finishing calico. It is not much used for calico-printing by machine, as the fine particles of grit which it generally contains is very injurious to the copper rollers.

Yellow Pigments.—*Lead Yellow* (Chromate of Lead), $PbOCrO_3$, is produced by the precipitation of a soluble lead salt by means of bichromate of soda, thus—

$$Na_2O2CrO_3 + 2PbON_2O_5 + H_2O = 2PbOCrO_3 + Na_2ON_2O_5 + 2HNO_3.$$

This pigment is largely used as an albumen colour; it is a bright and fast yellow, but blackens if exposed to sulphuretted hydrogen.

Lead Orange (Basic Chromate of Lead), Pb_2CrO_5, is formed when the yellow chromate of lead is boiled with lime water.

The basic chromate of lead is too red of itself for a good orange, but by mixing with the yellow chromate the right shade is got. These lead chromates are found in commerce in the form of a thick paste ready for use, and in order to test their value it is best to determine their colouring power by a practical printing trial.

Cadmium Yellow (Sulphide of Cadmium), CdS.—This is a good yellow pigment, but too expensive for ordinary printing. The advantage this yellow has over lead yellow is that it is not blackened by sulphuretted hydrogen.

Barium Yellow (Chromate of Barium), $BaOCrO_3$.—This pigment yellow has not got the colouring power of the lead yellow; therefore it is not much used, although very cheap and free from the objection of going black.

There are several other yellow pigments, but they are not nearly so good as lead yellow, and are, therefore, not much used.

Iron Buff is a pigment largely used by some printers, especially as a pad colour. It is imported into this country in the form of a thick paste which should be smooth and free from hard lumps and grit, and of a clear buff shade.

Red Pigments.—*Vermilion* (Sulphide of Mercury).—This is a very heavy, bright red powder; it is very expensive, and is often adulterated, the chief adulterant being vermilionette.

Vermilionette is a mixture of red lead, eosine, and some white pigment.

Red Lake is another substitute for vermilion; but none of these substitutes are equal to the genuine vermilion for printing indigo-blue discharge colours, the purpose for which vermilion is chiefly used.

Green Pigments.—*Guignet* or *Chrome Green* is the hydrate of chromium, $Cr_2H_6O_6$. This important pigment is prepared on a large scale by heating a mixture of bichromate of potash and boracic acid. The pigment is found in commerce as a paste ready for use. Although not a very bright green, it is largely used, because it is not nearly so poisonous as the other mineral greens; it is also a very fast colour, and stands strong acid, which is necessary when used in the indigo discharge style.

Scheele's Green (Arsenite of Copper) is a very bright pigment, but too poisonous to be used for calico-printing.

Blue Pigments.—*Ultramarine.*—This very important pigment was originally prepared by grinding to a fine powder the precious stone *Lapis lazuli*, but is now prepared artificially by a chemical process. Ultramarine comes into the market as a dry powder of a bright blue colour. The pigment not only varies in shade from a greenish to a rather violet blue, but is also very liable to adulteration with kaolin, sulphate of barium, &c., which reduce the strength of the colour. The difference in the strength and shade of samples of ultramarine can be seen by placing small quantities near together upon a sheet of white paper; but the most reliable test is to print the samples as albumen colours. The great advantage of ultramarine blue over all other bright blues is its fastness against air and light. Ultramarine blue is destroyed by acids.

Prussian or *Berlin Blue*, Fe_7Cy_{18}, is prepared by precipitating a solution of a ferric salt with a solution of ferro-cyanide of potash, according to the following equation—

$$2Fe_2Cl_6 + 3K_4FeC_6N_6 = Fe_7C_{18}N_{18} + 12KCl.$$

The commercial product is a dark blue paste. It is not much used in cotton printing.

Many other pigment colours were formerly in use, but they have been superseded by alizarine and other acid coal-tar colours, fixed with acetate of chrome and developed by the steaming process.

CHAPTER XI.—COAL-TAR COLOURS.

The very remarkable substance coal tar is the source of a large and most important class of colouring matters. Coal tar consists of a large number of different substances; the separation of these substances in the pure state forms a special branch of industry.

THE DISTILLATION OF COAL TAR.

The separation of the different constituents of coal tar is effected by means of fractional distillation, a process which depends upon the fact that, on heating a mixture of different liquids, the one which has the lowest boiling point will pass over first into the distillate, the others following in order according to their boiling points. The boiling points of the different constituents of coal tar vary considerably; it is, therefore, possible, by separating the fractions of the first distillation, to obtain certain constituents in the first fraction only, while others are contained in the second or third. The process of distillation is carried out in large iron retorts. The first distillate, containing all the products which pass over at a temperature not exceeding 180°, is technically known as light oil. The second fraction consists of heavy oil, so called because it sinks in water. The third fraction of the distillate is the so-called green grease or anthracene oil. Not one of the preceding three distillates consists of a pure and simple body, but each yields a typical substance. From the light oil we get benzene and its homologues; from the heavy oil, naphthalene; and from the green grease, anthracene.

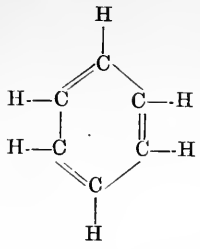
The coal-tar colours may be divided into three classes, viz.:—

1st. Benzene colours, comprising the so-called aniline dyes.

2nd. Naphthalene colours or azo dyestuffs.

3rd. Anthracene derivatives or acid colours, as alizarine, &c.

Benzene is a colourless liquid. Its specific gravity at 15° C. is 0·885. It boils at 80°, and is insoluble in water, dilute acids, and alkalies. Benzene may be regarded as the simplest representative of a large class of compounds which are known as "aromatic compounds," to which nearly all the artificial organic colouring matters belong. It consists of 6 atoms of carbon and 6 atoms of hydrogen; the carbon atoms are bound together in such a manner as to form what is known as the benzene ring, thus:—



C_6H_6

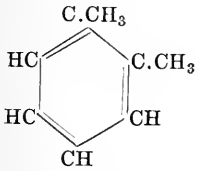
Symbolic ormula of benzene.

Graphic formula of benzene.

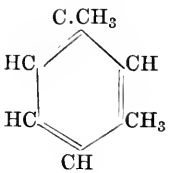
The benzene ring is very stable, and is only split up by very energetic chemical action.

Toluene, $C_6H_5CH_3$, is one of the homologues of benzene, and is obtained from the light oil by fractional distillation. If one of the hydrogen atoms of benzene is replaced by methyl (CH_3), methylbenzene, or toluene, is formed. Experience has shown that which ever hydrogen atom in the benzene ring is replaced, one and the same toluene is invariably obtained. Toluene is lighter than benzene. Its specific gravity is 0·872 at 15°. It does not solidify on cooling, and its boiling point is 111° C.

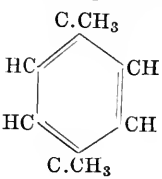
Xylenes, $C_6H_4(CH_3)_2$.—If two atoms of hydrogen in the benzene ring are replaced by methyl, three isomeric xylenes are formed which each possess the formula $C_6H_4(CH_3)_2$. They are distinguished from each other by their constitutional formulæ in the following manner:—



(1, 2.)

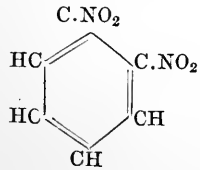


(1, 3.)

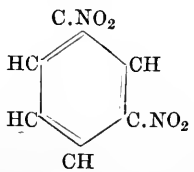


(1, 4.)

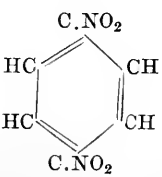
For convenience sake the carbon atoms of the benzene ring are numbered from 1 to 6, beginning usually at the top and proceeding to the right hand. By this means it is possible to express a constitutional formula without making a diagram. The position (1, 2) is known as the ortho, (1, 3) as the meta, and (1, 4) as the para position. The three xylenes referred to above are thus known as ortho-, meta-, and para-xylene respectively. As another instance, the three isomeric dinitrobenzenes would be shown thus:—



Ortho.



Meta.

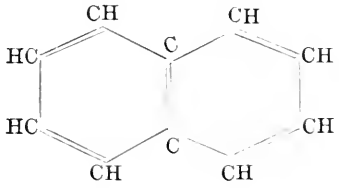


Para.

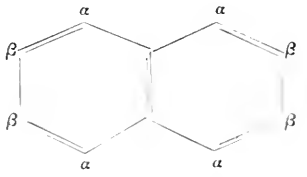
The xylene obtained from coal-tar consists of a mixture of the three xylenes, which can exist according to theory; but of these, metaxylene is present in by far the largest proportion. The boiling points of the three xylenes lie so near each other (about 140°) that a separation by fractional distillation is not possible.

Xylene is lighter than benzene or toluene. Its specific gravity is 0·866 at 15° C.

Naphthalene.—Naphthalene consists of white leaflets, which possess a peculiar smell and sublime slowly at the ordinary temperature. It melts at 79·2° and boils at 216°. The constitutional formula of naphthalene can be regarded as a double benzene ring, and is expressed as follows:—



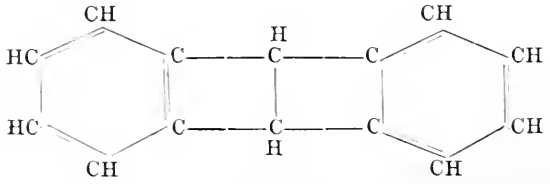
It will be seen in looking at this formula that in the formation of mono-substitution products two isomers are obtained, according as the hydrogen atoms marked β or those marked α are replaced in the following scheme:—



Thus by replacing one hydrogen atom by OH, two isomeric naphthols are obtained which are known as alpha-naphthol and beta-naphthol, but both possess the rational formula $C_{10}H_7OH$.

Anthracene, $C_{14}H_{10}$.—Anthracene forms leaflets with a violet fluorescence. They melt at 213° and boil at 360°.

Anthracene contains two separate benzene rings, which are joined together by the group C_2H_2. The constitution is shown in the following graphic formula:—



Aniline, $C_6H_5NH_2$, and **Toluidine,** $C_7H_7NH_2$.—These amines are obtained from benzene and toluene, by nitration and reduction of the resulting nitro bodies.

The nitration is effected, with certain precautions, especially with regard to temperature, with a mixture of nitric and sulphuric acids. If the mixture becomes too strongly heated, dinitro products are produced in place of the mononitro derivatives desired.

Nitrobenzene, $C_6H_5NO_2$, is formed according to the equation :—

$$\underset{\text{Benzene.}}{C_6H_6} + HNO_3 = \underset{\text{Nitrobenzene.}}{C_6H_5NO_2} + H_2O.$$

It is a yellow liquid, solidifying at + 3°, boiling at 213°, and is heavier than water (specific gravity 1·2). It possesses a smell resembling that of oil of bitter almonds, and is sometimes used in perfumery under the name of "artificial oil of bitter almonds," or "mirbane oil." The first name often leads to confusion with the benzaldehyde prepared from toluene, which is distinguished from the natural product by the name "artificial oil of bitter almonds."

In accordance with the benzene theory, there is only one mononitrobenzene, while there are three mononitrotoluenes, C_6H_4, NO_2, CH_3, which are distinguished as ortho (O), meta (M), and para (P) nitrotoluenes.

By nitration of toluene, a mixture of ortho- and para-nitrotoluene is formed, with only a very small quantity of the meta compound. A separation of these two nitrotoluenes is never carried out on a large scale.

Ortho-nitrotoluene is a liquid which boils at 223°. It solidifies at − 20°. Specific gravity, 1·17.

Para-nitrotoluene forms crystals which melt at 54°, and boil at 238°. The reduction of nitrobenzene and toluene is effected by iron and hydrochloric acid.

$$\underset{\text{Nitrobenzene.}}{C_6H_5NO_2} + 3Fe + 6HCl = \underset{\text{Aniline.}}{C_6H_5 . NH_2} + 3FeCl_2 + 2H_2O.$$

The ferrous chloride yields with the aniline, ferrous hydrate and aniline hydrochloride. The ferrous hydrate reduces more nitrobenzene, whilst the aniline hydrochloride acts on the metallic iron again, producing ferrous chloride and free aniline.

The reduction is carried out with the aid of a gentle heat. When it is over, slaked lime is added to decompose any aniline hydrochloride, and the product is then distilled with steam. The oily layer of the distillate is separated from the aqueous one, and purified by distillation.

Aniline, $C_6H_5NH_2$, is a colourless oil which boils at 183°. On exposure to the air it becomes brown. Its specific gravity is 1·03.

One part of aniline dissolves in 31 parts of water; it is easily soluble in alcohol, ether, &c. It is a good solvent for many substances

which are sparingly soluble in other liquids—*e.g.*, indigo. One method of purifying aniline blue is based upon its solubility in aniline oil.

Aniline is a very strong base, forming with acids well crystallised salts.

Ortho-toluidine is a liquid boiling at 198°, which does not solidify at −20°. Its specific gravity is nearly the same as that of water.

Para-toluidine forms leaflets which melt at 45°, and boil at 198°.

For the qualitative detection of toluidine in aniline, a small sample is shaken with water, and chloride of lime or sodium hypochlorite is added to the aqueous solution. The purple-violet solution is shaken with ether. In presence of toluidine the ethereal layer will assume a permanent brown colour, while the aqueous solution is blue.

This reaction furnishes, at the same time, an example of the property of aniline of yielding colouring matters by oxidation. The nature of the colouring matters formed depends upon the duration of the oxidation, the temperature, the proportions employed, and the quantity of toluidine in the aniline. The aniline oils of commerce are a mixture of aniline and ortho- and para-toluidine. They sometimes also contain xylidine, $C_6H_3(CH_3)_2NH_2$.

The following varieties are distinguished:—Pure aniline, or aniline for blue, with very little toluidine. Aniline for safranine contains 35 per cent. of aniline; the rest consists of toluidine and a little xylidine.

Aniline for red (red oil) contains 20 per cent. of aniline, 40 per cent. of para- and 40 per cent. of ortho-toluidine.

Toluidine is a mixture of ortho- and para-toluidine with very little aniline.

Naphthylamine, $C_{10}H_7NH_2$.—*Alpha-naphthylamine* forms fine needles, which melt at 50°, and possess a disagreeable smell; it is almost insoluble in water. It yields colouring matters by oxidation. In order to prepare it, naphthalene is heated with nitric and sulphuric acids, and the resulting alpha-nitronaphthalene, $C_{10}H_7NO_2$, is reduced with iron and hydrochloric acid. It serves for the preparation of magdala-red, the naphthylamine fancy colours on cotton, and some azo dyes.

Beta-naphthylamine forms white leaflets, which melt at 112°. It dissolves in hot water. It is prepared by heating fused beta-naphthol with gaseous ammonia. Some azo dyes are derived from it.

Aniline Salts.—*Hydrochlorate of Aniline*, $C_6H_5NH_2HCl$.—This salt is formed when aniline oil is neutralised with hydrochloric acid. It is largely manufactured and brought into commerce in the form of crystals. It is largely employed for cotton dyeing and calico-printing for the production of aniline black, a colour of great fastness.

The aniline group of colours is built upon what is called the methane type—that is to say, their constitution is expressed by formulæ similar to that of marsh gas or methane—

$$C\begin{cases}H\\H\\H\\H\end{cases}$$

Thus, para-rosaniline, one of the colour bases of magenta, has the formula—

$$C\begin{cases}C_6H_4NH_2\\C_6H_4NH_2\\C_6H_4NH_2\\OH\end{cases}$$

Magenta, and many of the basic aniline colours, are derivatives of two compound methanes, viz.:—

$$C\begin{cases}C_6H_5\\C_6H_5\\C_6H_5\\H\end{cases}$$

Triphenylmethane.

and

$$C\begin{cases}C_6H_4CH_3\\C_6H_5\\C_6H_5\\H\end{cases}$$

Tolyldiphenylmethane.

We have seen how benzene, by treatment with nitric acid, is converted into nitrobenzene, and also how nitrobenzene by reduction is changed into amidobenzene (aniline); in a similar way, triphenylmethane and tolyldiphenylmethane are converted first into the nitro and then into the amido compounds—

$$C\begin{cases}C_6H_5\\C_6H_5\\C_6H_5\\H\end{cases} + 3HNO_3 = C\begin{cases}C_6H_4NO_2\\C_6H_4NO_2\\C_6H_4NO_2\\H\end{cases} + 3H_2O$$

Triphenylmethane. Trinitrotriphenylmethane.

$$C\begin{cases}C_6H_4CH_3\\C_6H_5\\C_6H_5\\H\end{cases} + 3HNO_3 = C\begin{cases}C_6H_3\begin{cases}NO_2\\CH_3\end{cases}\\C_6H_4NO_2\\C_6H_4NO_2\\H\end{cases} + 3H_2O$$

Tolyldiphenylmethane. Trinitrotolyldiphenylmethane.

$$C\begin{cases}C_6H_4NO_2\\C_6H_4NO_2\\C_6H_4NO_2\\H\end{cases} + 18H = C\begin{cases}C_6H_4NH_2\\C_6H_4NH_2\\C_6H_4NH_2\\H\end{cases} + 6H_2O$$

Triamidotriphenylmethane.

$$C\begin{cases}C_6H_3\begin{cases}NO_2\\CH_3\end{cases}\\C_6H_4NO_2\\C_6H_4NO_2\\H\end{cases} + 18H = C\begin{cases}C_6H_3\begin{cases}NH_2\\CH_3\end{cases}\\C_6H_4NH_2\\C_6H_4NH_2\\H\end{cases} + 6H_2O$$

Triamidotolyldiphenylmethane.

These amido compounds, or "leuco bases" as they are called, are colourless, and yield colourless salts with acids; but by oxidation they are transformed into colour bases, which differ from the "leuco bases" by containing one atom of oxygen—

$$C\begin{cases}C_6H_4NH_2\\C_6H_4NH_2\\C_6H_4NH_2\\H\end{cases}$$

Triamidotriphenylmethane (para-leucaniline).

$$C\begin{cases}C_6H_4NH_2\\C_6H_4NH_2\\C_6H_4NH_2\\OH\end{cases}$$

Triamidotriphenylcarbinol (para-rosaniline).

The colour bases themselves are generally colourless. They unite with acid, with elimination of water, to form coloured salts, the real dyestuffs—

$$C\begin{cases} C_6H_4NH_2 \\ C_6H_4NH_2 \\ C_6H_4NH_2 \\ OH \end{cases} + HCl = C\begin{cases} C_6H_4NH_2 \\ C_6H_4NH_2 \\ C_6H_4NH_2 \\ Cl \end{cases} + H_2O$$

Chloride of para-rosaniline.

Aniline-red (*Magenta*).—Commercial aniline-red is not a uniform substance, but a mixture of the salts of two bases, rosaniline and para-rosaniline—

$$C\begin{cases} C_6H_3\begin{cases} NH_2 \\ CH_3 \end{cases} \\ C_6H_4NH_2 \\ C_6H_4NH_2 \\ Cl \end{cases}$$

Chloride of rosaniline.

$$C\begin{cases} C_6H_4NH_2 \\ C_6H_4NH_2 \\ C_6H_4NH_2 \\ Cl \end{cases}$$

Chloride of para-rosaniline.

The product employed in commerce is mostly the chloride, and is principally in the crystallised form. The acetate is often found in commerce; it is more expensive than the chloride, but it is generally purer and more soluble in water. Magenta has declined considerably in importance since the introduction of other red colouring matters derived from coal tar. This dyestuff is now seldom used as a self colour in printing, owing to its want of stability against light and soap. Azaleine, roseine, fuchseine, rubine, cerise, cardinal, amaranth, &c., are all more or less impure forms of magenta. Good magentas are well crystallised, dissolve in pure water without leaving any residue, and are quite free from arsenic.

Aniline Blue.

1st. *Spirit Soluble Blue.*—If the hydrogen atoms of the amido groups of magenta are replaced by organic radicals, the colour becomes violet or blue. The shade is bluer, the more hydrogen atoms are replaced in this manner. The finest product is the chloride of triphenylrosaniline, commonly called opal blue, the constitutional formula of which is probably—

$$C\begin{cases} C_6H_3\begin{cases} CH_3 \\ NH(C_6H_5) \end{cases} \\ C_6H_4NH(C_6H_5) \\ C_6H_4NH(C_6H_5) \\ Cl \end{cases}$$

2nd. *Water Soluble Blue.*—Spirit blue, on being heated with sulphuric acid, is easily transformed into sulphonic acids, some of which are soluble in water in the free state, others as their alkali salts.

The first blue soluble in water was prepared by Nicholson in 1862, and was called after him, "Nicholson's blue."

The more sulpho-groups introduced into triphenylrosaniline, the more easily soluble the products become; but their fastness decreases

in the same proportion, as regards the action of light, air, and soap. The higher sulphonic acids, such as rosaniline tetrasulphonic acid, $C_{38}H_{27}N_3(SO_3H)_4$, are, therefore, never prepared.

Alkali Blue.—The most important of the water soluble blues is alkali blue. It is the soda salt of the monosulphonate, $C_{38}H_{30}(SO_3Na)$.

Alkali blue comes into commerce as a brownish powder. It should dissolve without residue in about 5 parts of water. Alkali blue is largely used for dyeing wool and silk, though not for cotton dyeing; it is, however, sometimes used for printing on calico, acetate of chrome being the mordant for the printing colour.

Water Blue, or *Cotton Blue*, is the sodium salt of triphenylrosaniline-trisulphonate, $C_{38}H_{28}N_3(SO_3Na)_3$. It is principally used for cotton dyeing with a tannic acid mordant.

Aniline Violet.

Methyl Violet is the chloride of pentamethylated pararosaniline.

$$C\begin{cases} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_6H_4NH(CH_3) \\ Cl \end{cases}$$

This is the normal shade of violet (marked B), but there are many other shades manufactured, the bluer shades being marked 2B, 3B, &c., to 6B; the bluest shade is called *benzyl violet*, as it contains the radical benzyl which has replaced some of the methyl violets. Redder shades of violet are produced by mixing the methyl violet with magenta. The old Hofmann's violet has been replaced by the above violets.

Crystal Violet, a more recent production, is the chloride of hexamethylated pararosaniline, and gives a bluer shade than the pentamethylated pararosaniline. The following is its probable constitutional formula:—

$$C\begin{cases} C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ Cl \end{cases}$$

Aniline Greens.

The best of these is *malachite green*, which is known by various names, as Bengal green, solid green, Victoria green, &c.; its probable formula is

$$C\begin{cases} C_6H_5 \\ C_6H_4N(CH_3)_2 \\ C_6H_4N(CH_3)_2 \\ Cl \end{cases}$$

But a zinc chloride double salt of this green is easier to separate and crystallise, and is, therefore, found in commerce; in this form its composition is

$$3(C_{23}H_{24}N_2HCl) + 2ZnCl_2 + 2H_2O.$$

Malachite green is applied in the same way as other basic aniline colours.

Methylene Blue, $C_{16}H_{18}N_4SHCl$.—This is a very important product for cotton dyeing and calico-printing. The shades produced are from a light and bright blue to a dark indigo; they stand light and soaping fairly well, and, though not so bright as opal-blue shades, are preferred to these latter upon that account. It is best fixed with a tannin mordant.

Auramine, $(C_6H_4N(CH_3)_2)_2CNHHCl$.—This yellow basic aniline is used for cotton dyeing, and sometimes for printing. It is moderately fast—for a basic aniline—to light and soaping. The colour is soluble in hot water, but the solution must not be boiled, as the colouring matter is decomposed on boiling. It is fixed in the same way as other basic anilines. There are many other basic anilines, but they are of little use to the calico-printer.

Naphthalene Colours or Azo-Dyestuffs.—The very large number of colours included in this class, although extensively used by woollen dyers, can only be used to a very limited extent by calico-printers, as they do not fix upon the cotton fibre either with or without a mordant. The tetra-azobenzidine colours derived from benzidine are, however, an exception, as these dyestuffs very readily fix upon cotton even without a mordant.

If benzidine $\begin{pmatrix} C_6H_5NH_2 \\ | \\ C_6H_5NH_2 \end{pmatrix}$ is treated with nitrous acid it yields a tetra-azo compound, the chloride of which is represented by the formula

$$\begin{matrix} C_6H_5 - N = NCl. \\ | \\ C_6H_5 - N = NCl. \end{matrix}$$

This compound, which is the tetra-azodiphenyl dichloride, combines with aromatic amines and phenols to produce a series of colouring matters, which possess the peculiar but valuable property of dyeing vegetable fibres in a neutral or slightly alkaline bath without the intervention of a mordant. One of the first of the colours to be produced by this means was

Congo-red, which is obtained by combining naphthylamine sulphonate of soda, $C_{10}H_6NH_2SO_3Na$, with tetra-azodiphenyl chloride; it possesses the formula:—

$$\begin{matrix} C_6H_4 - N = N - C_{10}H_5NH_2SO_3Na. \\ | \\ C_6H_4 - N = N - C_{10}H_5NH_2SO_3Na. \end{matrix}$$

This colour possesses the fatal property (as a dye) of being blackened by the slightest trace of acid. This property, however, makes Congo-red valuable as an indicator in volumetric analysis; solutions of many metallic salts, such as alum, bluestone, copperas, &c., when pure, do not affect Congo-red in the least, while blue litmus is reddened by

them. Congo-red is, therefore, a valuable agent in the detection of free acid in these salts.

Benzopurpurine is a much better dyestuff than Congo-red, for although it has the same defect of being blackened by acids, it is not so very sensitive in this respect, as goods dyed with benzopurpurine will bear exposure to the atmosphere without changing colour, which is more than can be said for Congo-red.

Benzopurpurine is, unfortunately, not very fast to light, or it would be one of the best colours in existence; it is similar in constitution to Congo-red, being obtained by the action of naphthylamine sulphonate of soda upon the tetra-azoditolyl chloride, and possesses the formula—

$$\begin{array}{l} C_7H_6 - N = NC_{10}H_5NH_2SO_3Na. \\ | \\ C_7H_6 - N = NC_{10}H_5NH_2SO_3Na. \end{array}$$

Chrysamine—

$$\begin{array}{l} C_6H_4 - N = NC_6H_3(OH)COONa, \\ | \\ C_6H_4 - N = NC_6H_3(OH)COONa, \end{array}$$

is a type of the class of direct yellows (that is, colours which fix upon the cotton fibre without the aid of a mordant). Chrysophenine, brilliant yellow, Hessian yellow, &c., are other yellows of the same class; they are remarkably fast to soaping and light. As light pad colours they are very largely used by calico-printers.

Azo-blue—

$$\begin{array}{l} C_7H_6 - N = NC_{10}H_5OHSO_3K, \\ | \\ C_7H_6 - N = NC_{10}H_5OHSO_3K, \end{array}$$

the chemical name of which is tetra-azoditolylbetanaphthol sulphonate of potash.

Azo-blue is the representative of the class of direct blues, which include benzo-azurine, sulphonazurine, brilliant azurine, &c. These blues are fast to soaping, but only moderately fast to light.

There are many other shades of direct colours of the benzidine series, such as azo-violet, benzo-brown, benzo-olive, diamine-black, &c., any of these direct colours may be mixed together to form compound shades. It is very probable that these colours will ultimately replace all others. As already stated, the soluble diazo and oxyazo colouring matters cannot be fixed upon the cotton fibre; nor has the bisulphite solutions of the insoluble azo-dyes been a success. More or less successful attempts have, however, been made by Holliday, Græssler, Dawson, and others, to produce the insoluble azo-colouring matters directly upon the fibre.

The following example will serve to illustrate Græssler's patent:— In order to produce xylidine red, $C_6H_3(CH_3)_2 - N = C_{10}H_6OH$, on the fibre, a mixture of beta-naphthol, xylidine, sodium nitrite, and ammonium chloride, thickened with starch paste, is printed and steamed. The heat causes the xylidine to decompose the ammonium

chloride, when ammonia is liberated and xylidine hydrochloride is formed, which latter reacts with the sodium nitrite, so as to form sodium chloride and diazoxylene chloride—

$$C_6H_3\begin{cases}(CH_3)_2\\ -N=N\cdot Cl.\end{cases}$$

This combines in the nascent state with the naphthol to form xylidine red. The whole reaction is expressed by the following equations :—

$$\underset{\text{Xylidine.}}{C_6H_3\begin{cases}(CH_3)_2\\ NH_2\end{cases}} + \underset{\text{Beta-naphthol.}}{C_{10}H_7OH} + NaNO_2 + NH_4Cl$$

$$= \underset{\text{Scarlet.}}{C_6H_3\begin{cases}(CH_3)_2\\ -N=N.C_{10}H_6OH\end{cases}} + NaCl + 2H_2O + NH_3.$$

The Anthracene Colouring Matters.—Although the number of colouring matters obtained from anthracene is very limited, they all resemble each other so closely in their chemical properties, and at the same time differ so widely from the other coal-tar colours, that they form a natural group of the latter. In the free state they are almost insoluble in water, but are easily soluble in ammonia and caustic alkalies. With the alkaline earths and most metallic oxides they yield richly-coloured insoluble lakes. This behaviour towards bases indicates the acid nature of these colouring matters, and a more thorough examination will show that they contain free hydroxyl groups, and, therefore, belong to the phenols, hence they are sometimes spoken of as phenolic colouring matters.

The anthracene colouring matters can only be used with the help of mordants. The shades produced with them are much faster to soap, chloride of lime, dilute acids, and in most cases also to light, than those obtained with the other coal-tar colours, while, at the same time, they are faster than most of the natural colouring matters.

Manufacture of Alizarine.—The method usually adopted for the transformation of anthracene into alizarine is effected in three distinct operations. Anthracene is first oxidised to anthraquinone—

$$\underset{\text{Anthracene.}}{C_6H_4\begin{cases}CH\\ |\\ CH\end{cases}C_6H_4} + O_3 = \underset{\text{Anthraquinone.}}{C_6H_4\begin{cases}CO\\ CO\end{cases}C_6H_4} + H_2O.$$

The anthraquinone is next treated with sulphuric acid. Anthraquinone forms three sulphuric acid compounds—viz., monosulphonic acid and alpha- and beta-disulphonic acids ; and, according as one or the other is produced, a different result is obtained, since the monosulphonic acid compound yields pure alizarine, while the alpha-disulphonic acid produces flavopurpurine, and the beta-disulphonic acid yield anthrapurpurine. Anthraquinone-monosulphonic acid—

$$C_6H_4\begin{cases}CO\\ CO\end{cases}C_6H_3SO_3H$$

is formed when anthraquinone is heated to 160° C. with fuming sulphuric acid. If the quantity of sulphuric acid is increased without raising the temperature, the chief product of the reaction is the beta-disulphonic acid. But if the temperature be kept for some time at 180° to 185° C., the chief product will be the alpha-disulphonic acid—

$$SO_3H-C_6H_3\begin{matrix}CO\\CO\end{matrix}>C_6H_3SO_3H.$$

Alpha- and beta-anthraquinone disulphonic acids.

The next process in the manufacture of alizarine is heating in strong boilers at a temperature of 190° C. for twenty-four hours, a mixture of 3 to 4 parts of solid caustic soda with 1 part of anthraquinone monosulphonate of soda and a small quantity of chlorate of potash. The reactions take place according to the following equations :—

$$C_6H_4\begin{matrix}CO\\CO\end{matrix}>C_6H_3SO_3H + NaHO = C_6H_4\begin{matrix}CO\\CO\end{matrix}>C_6H_3SO_3Na + H_2O.$$

$$3C_6H_4\begin{matrix}CO\\CO\end{matrix}>C_6H_3SO_3Na + 9NaHO + KClO_3$$

$$= 3C_6H_4\begin{matrix}CO\\CO\end{matrix}>C_6H_2(ONa)_2 + 3Na_2SO_3 + 6H_2O + KCl.$$

The alizarate of soda is then neutralised with hydrochloric acid, when alizarine is set free, thus—

$$C_6H_4\begin{matrix}CO\\CO\end{matrix}>C_6H_2(ONa)_2 + 2HCl = C_6H_4\begin{matrix}CO\\CO\end{matrix}>C_6H_2(OH)_2 + 2NaCl.$$

Alizarine.

Commercial alizarine is always sold in the form of a paste, containing 20 per cent. of the colouring matter in a very fine state of division. It usually goes by the name of blue shade of alizarine, as it gives with alumina mordant a bluish shade of red; with smaller quantities of alumina mordant very good pinks are obtained. With iron mordant good fast violets are produced.

If beta-anthraquinone disulphonate of soda be melted with caustic soda and chlorate of potash, then *anthrapurpurine*

$$OHC_6H_3\begin{matrix}CO\\CO\end{matrix}>C_6H_2(OH)_2$$

is produced. If alpha-anthraquinone disulphonate of soda be melted with caustic soda and chlorate of potash, then we get *flavopurpurine*, which has the same formula as anthrapurpurine.

A mixture of flavo- and anthrapurpurine goes by the name of "yellow shade of alizarine," because it gives yellower shades of red than those produced by means of pure alizarine. Yellow shades of alizarine must not be used for violets, as they do not yield good shades. The principal combinations of alizarine with metallic oxides are the following :—

Reds and pinks, with alumina.
Purple or violet and lilacs, with oxide of iron.
Chocolates, with mixtures of alumina and oxide of iron.
Clarets, with oxide of chromium.
Oranges, with oxide of tin.

The valuation of the alizarines is usually effected by estimating the percentage of dry substance and the ash, and by carrying out comparative dye trials. In estimating the percentage of dry substance, it should be borne in mind that the temperature should not be allowed to rise much above 100°, since alizarine begins to sublime at 110°. The residue should appear yellow and not dark brown. Alizarine pastes sometimes contain glycerine, Turkey-red oil, &c., which have been added in order to thicken the paste. These can be separated from the colouring matters by diluting with water and filtering. The filtrate may contain, besides, small quantities of salts, which have not been properly removed in the manufacture. It should have neither a brown nor a reddish tinge, but should be perfectly colourless. The ash should not weigh more than 1 per cent. of the dry alizarine, and should be free from iron.

Alizarine Orange, $C_6H_4 = CO = C_6H(OH_2)_2NO_2$, is prepared from alizarine by treating that substance with nitrous fumes; its chemical name is, therefore, nitro-alizarine. Alizarine orange is used chiefly in calico-printing as a steam colour, and is fixed, like alizarine, by means of a basic mordant. With alumina (as sulphocyanide) a good bright orange is produced if the cloth be well oiled. With acetate of chrome as the mordant alizarine orange gives a good brown shade; these colours are remarkably fast to light, and stand soaping well. Colours made with alizarine orange do not keep so well as those made with alizarine, as the nitro-alizarine is a much stronger acid, and has a great tendency to combine with the metallic bases to form lakes, even in the cold. Alizarine orange is found in commerce as a paste, containing 20 per cent. of the dry colouring matter; it is valued in the same way as alizarine.

Alizarine Blue is a derivative of nitro-alizarine, from which it is obtained by treatment with glycerine and sulphuric acid—

$$C_6H_4\begin{cases}CO\\CO\end{cases}C_6H(OH)_2NO_2 + \begin{matrix}CH_2OH\\|\\CHOH\\|\\CH_2OH\end{matrix}$$

Nitro-alizarine. Glycerine.

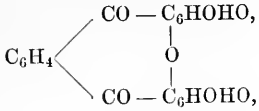
$$= C_6H_4\begin{cases}CO\\CO\end{cases}\overbrace{C_6(OH)_2}\begin{matrix}N=CH\\CH=CH\end{matrix} + 2H_2O + O_2.$$

Dioxyanthraquinone quinoline or Alizarine blue.

Alizarine blue is used as a steam colour in calico-printing, with acetate of chrome and lime as a mordant; the colour is not very bright, and

is only moderately fast to light. For cotton dyeing it is neither as good nor as cheap as indigo. Alizarine blue combines with sodium bisulphite to form *alizarine blue S*, a dry powder which is soluble in water. This is the form in which it is now generally used.

Cœruleine or anthracene green—probable constitutional formula—



is not obtained from anthracene, but by the dehydration of gallein—

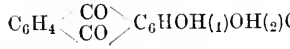
$$C_2OH_{10}O_7 - OH_2 = C_{20}H_8O_6.$$

However, since cœruleine has the constitution and properties of an anthracene derivative, it may well be classed with anthracene colours. Cœruleine, if fixed with a chrome mordant, is remarkably fast to light and soaping, but the shade it gives is rather an olive than a green; it is also a rather expensive colour. Cœruleine is found in commerce both in the form of a paste and also as a dry powder; the latter is the sulphite compound, and is known as *cœruleine S*.

Gallocyanine (Durand & Huguenin).—Chloride of dimethylphenylammoniumdioxyphenoxazin carbonic acid,

obtained by acting with nitrate of nitrosodimethylaniline upon gallic acid or tannin (1881—H. Koechlin) is a greenish-grey paste, which when dried gives a bronze-coloured powder. It is insoluble in water, soluble in alcohol to a blue-violet solution, in strong sulphuric acid to a pale bright blue solution; on diluting with water gives a bluish-red solution; soluble in hydrochloric acid to a crimson-red solution, in caustic soda to a red-violet solution. Dyes chrome-mordanted wool blue-violet shades, fairly fast to acids, light, and washing. Applied in calico-printing with a chrome mordant. Known also as *solid violet*.

Anthragallol—Anthracene Brown—Alizarine Brown.—Trihydroxyanthraquinone,



is formed by heating a mixture of gallic acid, benzoic acid, and sulphuric acid together. It is isomeric with anthrapurpurin, crystallises in yellow needles, and sublimes at 290° C.; it is slightly soluble in water, readily in alcohol, and in alkalies to a green solution. Alizarine browns come into the market as brown pastes. They give, with chrome mordants, rich nut browns; with alumina mordants, redder shades of brown; and with iron mordants, deep full browns. The most suitable brands to use are anthracene brown (Badische), anthracene brown W or G (Farbenfabriken), or alizarine brown paste (Farbwerke).

Alizarine Yellow GG (Meister, Lucius, and Brüning).—*M*-nitrobenzene azo-salicylic acid,

$$C_6H_4NO_2N.NC_6H_3OHCOOH,$$

is obtained by combining *m*-diazonitrobenzene with salicylic acid (1889). The pure product crystallises from alcohol in pale yellow needles, m.p. 230° C. It is very slightly soluble in cold, easily in hot, water. The commercial product is in the form of a yellow paste, containing about 20 per cent. of colouring matter. Cotton, mordanted with alumina or chrome, may be dyed. For printing, the printing colour is made with starch and tragacanth thickening, acetate of chrome, acetic acid, and colouring matter, printed and steamed.

Alizarine Yellow R (Meister, Lucius, and Brüning).—*P*-nitrobenzene azo-salicylic acid,

$$C_6H_4NO_2N.NC_6H_3OHCOOH,$$

is made by combining *p*-nitrodiazobenzene with salicylic acid (1890). Its properties and uses are similar to those of alizarine yellow GG, but it gives brownish-yellows on chrome-mordanted fibres.

Galloflavine (Badische) is prepared by oxidising gallic acid in alkaline, aqueous, or alcoholic solution with air (English patent, 6,413, 1886). It is a greenish-yellow paste, insoluble in water, very slightly soluble in alcohol; the solution has a pale yellow colour and weak green fluorescence. It is soluble in strong sulphuric acid to a scarlet solution; on diluting with water a greyish precipitate is obtained. Hydrochloric acid added to the paste, diluted with water, causes little change; caustic soda turns it red. Dyes wool and silk mordanted with chrome yellows, and is fast to light and soap. When applied in calico-printing with a chrome mordant, it gives greenish-yellow shades, which are fast to light and soaping.

Alizarine Black S (Badische) is a sodium bisulphite compound of naphthazarine—

$$C_{10}H_4(OH)_2\begin{matrix}O\\O^1\end{matrix}> + NaHSO_3.$$

Naphthazarine or dioxynaphthaquinone is formed by treating dinitronaphthalene with zinc and strong sulphuric acid, and this, when acted on by sodium bisulphite, yields alizarine black S. Alizarine black comes into the market in the form of either a powder or paste, and gives, with chrome or iron mordants, deep bright jet blacks of great beauty, which are exceptionally fast to light, soap, and acids. The best brand to use is alizarine black SRW paste, manufactured by the Badische Anilin and Soda Fabrik.

The Farbenfabriken vormals F. Bayer & Co., Elberfeld, send into the market some very useful colouring matters, which are of the alizarine group, and are similar in point of application and fastness to air, light, and washing. They are easier to fix than the alizarines, and for dark Bordeaux and indigo shades are, if anything, superior. The blues obtained from the alizarine cyanine are exceptionally fine, and

on wool they are certainly improved by milling. They are applicable also for calico-printing, and give fine results.

Alizarine Bordeaux is sent into commerce in four distinct shades—a blue shade of Bordeaux or claret, as alizarine Bordeaux B; a red shade, as alizarine Bordeaux R; and two yellow shades, as alizarine Bordeaux G and G G. These products are obtained from ordinary alizarine by heating it with fuming sulphuric acid, when the sulphur trioxide acts as an oxidising agent and forms tetraoxyanthraquinone, from which the alizarine Bordeaux is obtained. By using various brands of alizarine the various shades above named are obtained. These are identical with the chinalizarine obtained by Liebermann some time ago. It is a brownish-red paste, insoluble in water, but soluble in strong sulphuric acid to a purple solution; on dilution it forms a red-brown; caustic soda produces a violet solution.

Alizarine Cyanine.—This colour is sent into the market in various shades (marked R and G) of blue, superior to alizarine blue in respect of application and strength, being also faster, especially in light shades. It is produced by still further oxidising alizarine Bordeaux with manganese dioxide and fuming sulphuric acid, when alizarine cyanine or pentaoxyanthraquinone is produced. By working at higher temperatures more fully oxidised bodies are obtained and are used as dyes. Thus alizarine cyanine RRR double is a brownish-red paste, which gives with chrome mordants fine purple shades; with alumina mordants, maroons; and with iron mordants, very rich full purples. Alizarine cyanine R is a brown paste, giving with chrome mordants bright blues; with alumina mordants, magenta-coloured shades; and with iron mordants, greyish-blues. Alizarine cyanine GG is a brown paste, giving with chrome mordants, corn flower blues; with alumina mordants, lilac shades; and with iron mordants, stone greys. Alizarine cyanine G extra is also a brownish coloured paste which gives with chrome mordants, blues; with alumina mordants, reddish-purples; and with iron mordants, steel greys.

CHAPTER XII.—DYEING.

Indigo Dyeing—*The Blue Vat.*—Indigo, unlike the bulk of dye-wares, is, as such, insoluble in liquids which the dyer can employ. If treated with sulphuric acid, indeed, it is rendered soluble in water, and can be used for dyeing blues on animal fibres and tissues. But it has undergone a change which very seriously interferes with its most valued property—its fastness.

In order to fix unaltered indigo-blue upon the fibre, we take advantage of the circumstance that this indigo-blue or indigotin, in the presence of certain agents, is reduced to a white compound (known as indigo-white), which is soluble. Fibres or tissues are then steeped in the solution, taken out and exposed to the air, when the white indigo adhering to their surfaces becomes re-oxidised and remains permanently attached to them as indigo-blue.

There are various agents by which indigo can be reduced to the white soluble condition. That generally selected for cotton dyeing is copperas, the sulphate of protoxide of iron (ferrous sulphate) in presence of lime. The copperas, in contact with lime yields hydrated protoxide of iron (ferrous oxide), which greedily absorbs oxygen from any substance with which it comes in contact, and in this way reduces the indigo.

The indigo to be used in setting a vat is generally first broken up into small fragments, wetted with hot water, and then ground to a paste in a peculiarly constructed mill. The chief features of this mill are a strong iron cylinder, capable of being made to revolve rapidly on an axle, and smaller, solid, very heavy iron rollers placed within. Sometimes, instead of the rollers, there are three heavy iron globes like cannon balls. The moistened indigo being introduced, the cylinder is made to rotate by steam-power, and the indigo is ground to a fine uniform pulp by the action of the rollers or of the balls. It should be reduced to a perfectly creamy paste, quite free from fragments. If such remain, they generally escape thorough reduction and solution in the vat, and are consequently wasted. The lime should be of the best quality, recently burnt, fresh slaked, and sifted. The dyer in setting his vat should know how much actual dry indigo is contained in a gallon of his fine pulp. The vats are generally made of flag-stones or slate, well jointed and clamped together, and secured by cement. As the copperas vat used for vegetable fibres is worked in the cold, no heating arrangement is needed. The size of the vats

differ. In large establishments they are often 9 feet long and deep, by 3½ feet wide, and are conveniently arranged in sets of ten. In small dye works wooden tubs are often used.

The proportions of the materials may vary within certain limits. A common proportion is—ground indigo, 80 lbs.; copperas, 120 lbs.; lime, 160 lbs. The vat is filled with water, the lime added and well stirred up, so as to form a uniform milk of lime. The indigo is next stirred in, and the solution of the copperas is gradually added, still stirring. When the mixture is thoroughly made, the whole is left for some hours, but with occasional stirring. As soon as it turns a yellow with an olive cast it is ready for use.

The dyeing process is very simple. The yarns or pieces are first wetted out uniformly with water and then taken through the weakest or the most nearly exhausted vat which is on hand, proceeding thence to a stronger and stronger vat till the shade is reached. With piece-goods especially it is of importance that they should enter the vat evenly and uniformly, so that all parts may take up an equal proportion of the liquid. The next step is exposure to the air for as long a time as the dyeing process itself has lasted—*i.e.*, from five to fifteen minutes. Next, the goods are taken through weak vitriol sours, passed into cold water, and dried.

The *New Indigo Vat* (Schützenberger and De Lalande's Patent) is set as follows:—

A solution of bisulphite of soda at 49° to 59° Tw. is placed in a covered vessel containing zinc clippings, borings, &c., heaped up loosely so as to fill the tank without occupying more than a quarter of its total contents. After these ingredients have remained in contact for an hour the liquid is drawn into a cistern containing milk of lime, which decomposes the zinc salt. The clear liquid is strained off, soda or lime sufficient to dissolve the reduced indigo is added, and the indigo, finely ground as usual, is stirred in. During all this process access of air is avoided as much as possible. In this manner 1 lb. indigo may be dissolved in 1 to 1½ gallons of liquid. The vat is then filled with cold water if for cotton, and with hot water if for wool, and a suitable amount of the indigo solution is added. An excess of the hydrosulphite is always present, whence the blue scum (flurry) formed on the surface by the action of the air on the reduced indigo solution in the ordinary process is almost entirely avoided. The dye thus resists the action of the atmosphere better than the ordinary copperas vat, and is free from the inconvenience of holding in suspension more or less peroxide of iron, lime, carbonate of lime, &c. By adding to the dye-bath from time to time a little concentrated indigo solution, the strength can be maintained at any required point, and thus any given shade may be got with the smallest number of dips, the tints being brighter than those produced by the old process.

No. 1.—Dark Indigo, and No. 2.—Light Indigo or Sky.

A better and cheaper vat than that of Schützenberger and De Lalande is prepared as follows:—Into an iron pan of about 200 gallons capacity put 40 lbs. of well-ground indigo, 80 lbs. of slaked lime, 10 lbs. of caustic soda, and add hot water until the whole measures 70 gallons and is at a temperature of 140° F.; lastly, add 20 lbs. of zinc powder. Rake the mixture well up about every three hours, when the indigo will be found to have dissolved in from twelve to twenty-four hours, according to the temperature of the room and the degree of fineness to which the indigo has been ground. Next into a 12-gallon tub draw 10 gallons of bisulphite of soda of good quality, about 70° Tw. To this add 10 lbs. of zinc powder, stirring well all the time the zinc is being added to the bisulphite, and for five minutes after. This mixture is to be then poured immediately into the pan containing the 70 gallons of reduced indigo. After a final raking up the whole is allowed to settle for one hour, when it will be ready for use. Of course the above is a very strong solution of indigo—containing 8 ozs. of indigo per gallon—and is, therefore, much too strong for the purpose of dyeing as it is, but all that is required is to add the strong solution to water until the proper strength is obtained. 1 oz. or $1\frac{1}{2}$ oz. of indigo per gallon is a good strength for dark shades of blue; but for light blues (sky), from $\frac{1}{8}$ to $\frac{1}{4}$ oz. per gallon will be quite sufficient.

Indigo is now frequently combined with indophenol, which has similar dyeing properties, this combined vat being somewhat cheaper than pure indigo; but it will not stand the acid treatment.

No. 3.—Dark, and No. 4.—Light Iron Buffs and Creams.

1st. Pass the goods through stannate of soda at $\frac{1}{4}$° Tw. for light creams to 8° Tw. for strong buffs.

2nd. Pass them through ferric sulphate at from $\frac{1}{8}$° Tw. to 8° Tw., according to shade required, and wash off immediately. Dyeing with these colours is best done on the padding mangle (shown in the accompanying plate).

No. 5.—Dark, and No. 6.—Light Prussian Blues.

These colours are produced by dyeing up the above iron buffs in a solution of yellow prussiate of potash, $\frac{1}{2}$ lb. per gallon, adding 2 ozs. sulphuric acid per gallon; wash before drying.

No. 7.—Lead Yellows.

These colours are produced by first padding with acetate of lead, from about 4 ozs. to 1 lb. per gallon (which operation can best be done on a padding mangle). The yellow is then raised by a solution of

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bichromate of soda, 4 ozs. per gallon. Sometimes the lead is fixed with lime water before raising in the chrome; but this is better omitted in the case of printed goods.

No. 8.—Catechu Browns.

Dyeing with these colours is best done in the jigger (see p. 40).

6 pieces = 72 lbs.

16 lbs. catechu.
3 lbs. sulphate of copper.
10 gallons of water.

Boil well before entering goods. Give 6 ends, then recharge the jigger with

10 gallons of boiling water, and
2½ lbs. bichromate of soda.
Give 4 ends, wash, and dry.

By reducing the amount of catechu, paler shades of brown, even buffs and creams, may be produced. By adding sumach a great variety of shades may be produced by dyeing with anilines, &c. The following are a few examples :—

No. 9.—Bright Shade of Brown.

6 pieces = 72 lbs.

12 gallons water.
12 lbs. catechu.
10 lbs. sumach.
2 lbs. sulphate of copper.
Boil well; give 6 ends, and recharge with
10 gallons of boiling water, and
2½ lbs. of bichromate of soda.
Give 4 ends, and wash; then recharge jigger with
10 gallons warm water.
10 ozs. perchloride of tin.
Give 2 ends, then add
4 ozs. Bismarck brown.
Give 4 ends; wash, and dry.

No. 10.—Red Shade of Brown.

As last recipe, but using magenta in place of Bismarck brown.

No. 10*a*.—Yellow Shade of Brown.

As last recipe, but using auramine in place of Bismarck brown.

No. 11.—Dark Brown.

6 pieces = 72 lbs.

12 gallons water.
12 lbs. catechu.
10 ,, sumach.
2 ,, sulphate of copper.
Boil well, and give 6 ends, then recharge jigger with

10 gallons boiling water.
2½ lbs. bichromate of soda.
Give 4 ends, wash, and recharge jigger with
12 gallons of water, and
1 gallon iron liquor.
Give 4 ends; then wash, and dry.

No. 12.—Slate.

This shade is best produced in the jigger from logwood and copperas.

6 pieces = 72 lbs.
16 gallons water,
6 lbs. extract of logwood.
2 ,, ,, bark.
Give 4 ends at 140° F., then recharge jigger with
16 gallons cold water, in which is dissolved
10 lbs. copperas (ferrous sulphate).
Give 4 ends, and dry.

No. 13.—Greys.

These are produced the same way as slate, only using less of the extracts and copperas, and sometimes modifying the shade with catechu, fustic, sumach, &c.

Drabs.

These are complex shades produced in the same way as slates and greys, using, of course, rather different ingredients.

No. 14.—Dark Drab.

6 pieces = 72 lbs.
8 lbs. catechu.
2 ,, peachwood extract, dissolve in
12 gallons water.
Give 4 ends, recharge with
12 gallons water.
2 quarts black liquor.
Give 4 ends; wash, and dry.

This can be turned to a yellower shade by adding fustic liquor along with the catechu, or browner by topping up with Bismarck brown.

No. 15.—Light Drab.

6 pieces = 72 lbs.
5 lbs. sumach.
5 ,, ground fustic.
½ lb. logwood extract.
¼ ,, annatto.
16 gallons boiling water.
1 quart black liquor.
1 ,, nitrate of iron, 64° Tw.
Give 4 ends; wash, and dry.

No. 16.—Dark Blue.

6 pieces = 72 lbs.

8 lbs. sumach.
1 lb. logwood extract.
16 gallons boiling water.
Give 4 ends, then recharge with
10 gallons cold water.
1 gallon nitrate of iron, 64° Tw.
Give 4 ends, and charge again with
12 gallons water.
3 lbs. yellow prussiate of soda.
8 ozs. vitriol.
Give 4 ends, and wash, charge again with
16 gallons water.
3 ozs. BB violet.
3 ,, methylene blue.
Give 6 ends, and dry.

No. 17.—Prussiate Green.

6 pieces = 72 lbs.

8 lbs. alum.
2 lbs. common soda.
12 gallons warm water.
Give 2 ends, recharge with
6 lbs. bark extract, dissolved in
12 gallons water at 160° F.
Give 8 ends, and recharge with
12 gallons cold water.
1 quart nitrate of iron.
Give 4 ends, and recharge with
12 gallons cold water.
2 lbs. yellow prussiate.
½ lb. vitriol.
Give 4 ends, wash, and dry.

No. 18.—Chrome Black.

6 pieces = 72 lbs.

14 lbs. sumach.
12 lbs. myrobolans.
12 gallons boiling water.
Give 8 ends at boil, recharge with
10 gallons cold water.
2 lbs. sulphate of copper.
2 quarts black liquor.
Give 4 ends, and wash; charge again with
10 gallons hot water.
4 lbs. bichromate of soda.
Give 4 ends, and wash. Give 8 ends in jigger at boil with
4 lbs. logwood extract.
2 lbs. fustic extract.
12 gallons water.
Wash, soap, and dry.

No. 19.—Sumach Black.

6 pieces = 72 lbs.

14 lbs. sumach.
12 gallons boiling water.

Give 8 ends, and recharge with

10 gallons cold water.
1 gallon black liquor.
2 lbs. ground chalk.

Give 6 ends. Give 4 ends in lime water, wash, and recharge with

4 lbs. logwood extract.
½ lb. bark extract.
12 gallons boiling water.

Give 6 ends, add 4 lbs. copperas, and give 2 more ends; wash and dry.

No. 20.—Fast Blue Black.

6 pieces = 72 lbs.

Give a ground in the indigo vat, sour off and wash, then work in jigger with

10 lbs. sumach.
12 gallons boiling water.

Give 4 ends, and recharge jigger with

10 gallons water.
2 quarts black liquor.

Give 4 ends and then 2 ends in lime water, and wash; recharge jigger with

12 gallons boiling water.
2 lbs. logwood extract.

Give 4 ends, then add

1 quart black liquor.
2 lbs. sulphate of copper.

Give 2 more ends; wash, and dry.

Aniline Blacks.—These shades are best produced on the printing machine with a pad roller (see recipe for printing, p. 35).

No. 21.—Alizarine Red.

1st. Pad on padding mangle with

16 gallons cold water.
1 gallon oleine oil.
1 quart stannate of soda, 40° Tw.

Dry on the cylinders.

2nd. Pad again on padding mangle with acetate of alumina (red mordant), 8° Tw. Dry on the cylinders.

3rd. Pass through the ageing machine, or hang in a warm room (75° F.) for two days.

4th. Run through dunging cisterns charged with a solution of phosphate of soda, ½ oz. per gallon, and 1 lb. of ground chalk to every 100 gallons, at a temperature of 150° F.

5th. Dye in spiral dye-beck with alizarine 8 lbs., oleine oil 2 lbs., tannic acid ½ lb., for every 100 lbs. cloth, starting at 25° C. and going to 70° C. during one and a-half hours; dry up out of dye-beck without washing.

6th. Oil on padding mangle with 16 gallons of water to 1 gallon oleine oil, and dry on the cylinders.

7th. Steam at 5 lbs. pressure.

8th. Soap with good neutral soap, about 4 lbs. per 100 lbs. cloth, in spiral dye-becks; wash and dry.

If it were not for the expense of the mordanting, the above process would answer very well for yellows, oranges, greens, blues, and many other shades, by dyeing up with flavine, alizarine orange, cœruleine, alizarine blue, &c. But as the tendency is towards rapid and cheap productions, these complex processes will have to give place to the simpler methods of dyeing with the direct colours—that is, with colours that require little or no mordanting upon cotton cloth.

DIRECT COLOURS.

For dark shades, dyeing with these is best done in the spiral dye-beck; for medium shades the jigger may be used; but for very light shades and pads the padding mangle with a very even nip is the best. These dyestuffs all work best if dissolved in condensed water. Hard water is objectionable, as it forms an insoluble scum with these colours, which is both a waste of the colour as well as a cause of stains and streaks on the pieces when dyed. The addition of phosphate of soda to the dye-bath is a great advantage for these colours, especially if hard water is to be used.

No. 22—Direct Red.

For 250 lbs. of cloth,

20 lbs. benzopurpurine,

40 lbs. phosphate of soda are dissolved in 500 gallons water, and filtered; dye at 170° F. for one hour.

As only about 10 lbs. of the benzopurpurine will be removed from the dye-beck, another 250 lbs. of cloth can be dyed by adding

10 lbs. of benzopurpurine,

20 lbs. of phosphate of soda dissolved in 150 gallons of water, and filtered into the dye-beck.

After dyeing, the goods are run through cold water containing 2 gallons of oleine oil to every 100 gallons of water; they are then dried without any further washing.

No. 23.—Direct Blue.

Use benzoazurine in place of benzopurpurine in the last recipe, taking the same quantities and working just as for direct red.

No. 24.—Direct Yellow.

Just as for direct red, but giving 15 lbs. chrysamine in place of 20 lbs. benzopurpurine for first dye, and adding 8 lbs. chrysamine for each batch of 250 lbs. of cloth after the first.

As is well known, there are a great number and variety of these direct dyeing colours now in use, so that almost any shade may be dyed with them; but as most of them may be used for dyeing in the

same way as benzopurpurine, there will be no necessity to give more examples. A great advantage of these direct colours is that, being of a similar nature, they can be mixed together in any proportion and worked together so as to produce almost any shade that may be wanted. For instance, benzoazurine is rather redder in shade than indigo, but by mixing 100 parts of benzoazurine with 2 or 3 parts of chrysamine a very good indigo shade is produced. There is, however, a great drawback to the use of mixed direct colours in dyeing; the beck is not exhausted, but one colour may be taken up more readily than another. For instance, in the mixture for indigo-blue shade, suppose we start with 100 ozs. of benzoazurine and 3 ozs. of chrysamine in the beck, the first batch of cloth may remove say 40 ozs. of benzoazurine and say 2 ozs. of chrysamine; hence, if we make the beck for the next batch by adding benzoazurine and chrysamine in the proportion of 100 parts of the former to 3 parts of the latter, it will be quite evident that we shall not get quite the same shade upon the second batch of cloth as we had upon the first; and the difference of shade will increase with every batch dyed, unless the dyer uses very great care and judgment in making up his dye-bath so as to keep to the original proportion of colours.

Various assistants are recommended for use with the direct colours, such as carbonate of potash, common soda, borax, silicate of soda, stannate of soda, Glauber's salt, common salt, &c., but the writer has found phosphate of soda to answer best in almost every case. The direct colours are of great service to calico-printers for getting very cheaply good light pad colours, such as creams, buffs, yellows, and, in fact, almost any light pad shade. These are, as before stated, done in the slop-padding mangle, and are very much cheaper and better than when done on the printing machine, as no thickening or steaming is required; all that is necessary is a good even nip on the mangle, and that everything about the mangle be kept perfectly clean. The colouring matter, with twice its own weight of phosphate of soda, is dissolved in condensed water—*i.e.*, water from the drying tins. There will be no necessity to give a large number of recipes for these pad colours as they can easily be made up to match the shade required, but the following will serve as an example:—

No. 25.—Cream Pads.

$1\frac{1}{4}$ oz. chrysamine G.
$\frac{1}{8}$,, benzo orange.
3 ozs. phosphate of soda.
80 gallons condensed water;
Or, for lighter creams, 160 gallons condensed water.

No. 26.—Buff Pads.

Increase the amount of colouring matter and phosphate, but in the same proportion as for creams. These creams and buffs are much pre-

ferable to those got from iron liquor as they do not affect any of the print colours, as is the case with the latter. Of course, they could be worked on the printing machine with an ordinary pad roller by thickening the above solutions with 8 ozs. of wheat starch per gallon.

As light pad colours very soon fade when exposed to light, it is most desirable that only those colouring matters which are known to be very fast against light should be used for them. However, owing to their adaptability for the purpose, it is very likely that in future none but the direct colours will be used as pad colours, especially so now that we have such colours as chrysamine, chloramine yellow, chloramine orange, chloramine brown, geranine pink, benzo-black-blue 5 G, direct grey, &c., colours, which are very satisfactory both as regards their fastness against light and washing, and also as to their ease of application and the great variety of shades which can be produced by mixing them together in various proportions.

No. 27.—Fast Cream Pad.

1¼ oz. chrysamine.
½ ,, chloramine orange.
3 ozs. phosphate of soda.
80 gallons condensed water.
Dilute with water for lighter shades.

No. 28.—Fast Buff Pad.

4 ozs. chrysamine.
2 ,, chloramine orange.
12 ,, phosphate of soda.
80 gallons water.

No. 29.—Old Gold Pad.

6 ozs. chrysamine G.
6 ,, chloramine orange.
1½ oz. benzo-black-blue 5 G.
1½ lbs. phosphate of soda.
80 gallons water.

Most of the direct colours are improved as to their fastness against soaping and light, by an after treatment with a hot solution of bichromate of soda and sulphate of copper, but the shades are much altered by this treatment, and, of course, for pad colours upon prints this process could not be made use of; the best plan, therefore, is to select those colours only which will stand without any further treatment.

No. 30.—Fast Bright Olive Green Pad.

12 ozs. benzo-black-blue 5 G.
6 ,, chrysamine G.
2 lbs. phosphate of soda.
80 gallons condensed water.

No. 31.—Fast Yellow Olive Pad.

3 ozs. benzo-black-blue 5 G.
3 ,, chrysamine G.
6 ,, phosphate of soda.
80 gallons condensed water.

No. 32.—Fast Bright Pink Pad.

2 ozs. geranine BB.
4 ,, phosphate of soda.
80 gallons condensed water.

No. 33.—Fast Terra-cotta Pad.

4 ozs. geranine BB.
½ oz. chrysamine G.
8 ozs. phosphate of soda.
80 gallons condensed water.

CHAPTER XIII.—WATER—THEORY OF COLOURS—PRINTING.

WATER.

Quantity of Water.—The question of the water supply is of the utmost importance for a dye and print works. The first condition should be a **constant and plentiful supply**, and the second a no less important one, that the **quality** should be good. A great deal of experience is required in the discrimination of the proper water supply, and it requires a close acquaintance with the practical industry of the branches for which the water is required before we can decide as to a water being good or otherwise for a given purpose. For a bleach works the softest water is the best, while for some branches of dyeing a moderate degree of hardness may be beneficial, but as water can easily be made up to any degree of hardness at a very slight expense, there is no doubt but the softest and purest water obtainable is the best for a works doing all branches of bleaching, dyeing, and printing.

The **character** of a water may, to a great extent, be judged by mere inspection. If it has a brown colour due to organic matter from peat, &c., or if ochrey matter is deposited upon stones over which the water runs, it ought to be condemned. Water containing insoluble matter which readily settles out need not be objected to, provided the works are supplied with reservoirs large enough to allow the water to stand until it becomes clear. The colour of a water can be best seen by filling a thin glass flask and placing it on a sheet of white paper, and placing by its side a similar flask filled with pure distilled water. The two flasks should stand in a good diffused daylight. If the flask of water is allowed to stand in a warm place (with a stopper in the neck of the flask) for twenty-four hours, the amount of impurity which will settle out can then be seen; if, on removing the stopper from the neck of the flask, the water gives off a bad odour it probably contains sewage. But a water may appear quite clear and bright and yet contain many impurities in solution; the presence of acid or alkali can easily be detected by means of litmus paper, which is turned red by the former and blue by the latter, but water which is either distinctly acid or alkaline is unsuitable for a print and dye works. To determine the total amount of solid matter contained in water, proceed as follows:—Thoroughly clean, dry, and weigh a thin platinum dish

capable of holding 100 c.c.; 70 c.c. of the sample of water is put into the dish, and evaporated on a steam bath to complete dryness. The dish and contents are then reweighed, and the difference between this weighing and the first gives the amount of total solids, every milligramme being equal to 1 grain of solid matter per gallon of water. A very good water will not contain more than 25 grains of solid matter per gallon, though a water containing 100 grains per gallon might still be useable, as more depends upon the kind than on the quantity of matter contained. If, on gently heating the platinum dish and contents to a dull red heat, much empyreumatic odour is given off, and especially if, in summer time, the water appears green and full of small insects, it will not be good for bleaching purposes. If, after heating to a full red heat and then allowing the dish to cool, it is found to contain a brown residue, the water probably contains iron. To confirm the presence or otherwise of iron in the water, proceed as follows:—To the residue in the platinum dish add 2 c.c. of water and 1 c.c. of nitric acid, and wash this round the inside of the dish so as to moisten every part of it, and then again evaporate to dryness; now treat the residue with 10 c.c. of pure water, filter, and divide the filtrate into two parts; add a few drops of solution of gall nuts to one part, and a few drops of a solution of yellow prussiate of potash to the other; if the solution of gall nuts produces a black colouration or precipitate, and the yellow prussiate a blue colouration, iron is present in the water.

For the detection of lime and magnesia in water, proceed as follows:—In a large porcelain dish put about 1 pint of water, add a few drops of a solution of ammonium sulphide (to precipitate any iron that may be present), and evaporate to about 2 ozs.; filter, and to the filtrate add a solution of oxalate of ammonia; any white precipitate is due to the presence of lime. After standing about one hour the precipitated lime is filtered off, and a solution of phosphate of soda added to the filtrate, which will produce another white precipitate if magnesia be present.

Clark's Soap Test.—The hardness of water—that is, its power of destroying soap—is estimated by Clark's soap test. One of the most striking differences between different kinds of natural waters is their behaviour towards soap. Some waters destroy much soap before a lather is formed; such water is said to be hard. Other kinds of water require very little soap for the formation of a lather, and are, therefore, said to be soft. The first step towards the determination of the hardness of water is to make up a standard solution of soap by dissolving a convenient quantity of soap, say, 1 oz. of best curd soap in $\frac{1}{2}$ a gallon of methylated spirit, and $\frac{1}{2}$ a gallon of hot condensed water—after the soap is dissolved the solution is allowed to settle till quite clear, and poured off into stoppered bottles, in which it is preserved ready for use. The next step is to find the value of the soap solution. For this

purpose a standard hard water is made up by grinding 27½ grains of pure sulphate of lime (selenite) to a fine powder and dissolving it in exactly 1 gallon of distilled water (condensed water from the drying cylinders will do). This standard hard water (which is said to be 16° hard, because it contains what is equal to 16 grains of carbonate of lime in a gallon of water) is now tested against the soap solution as follows:—Into a clean 12-oz. stoppered bottle weigh 4 ozs. of the standard hard water. From a graduated burette filled with the soap solution run a small quantity into the bottle containing the 4 ozs. of standard hard water, close the mouth of the bottle with the stopper, and shake up well. If the froth produced on shaking rapidly disappears more of the soap solution must be run in from the burette. This addition of soap solution, stoppering and shaking must be repeated until at last a point is reached when a lather or froth is produced and remains without breaking up for at least five minutes, indicating that all the lime in the water has been precipitated in the form of an insoluble lime soap, when the test is completed. If we multiply the number of measures of soap solution used from the burette by 40 and divide the product by 16 the quotient will be the number of measures of soap solution corresponding to 1° of hardness. Having thus determined the relation between the standard hard water and the soap solution, the hardness of any sample of ordinary natural water may be tested in the same way or by comparison with the same quantity of standard hard water. If a water is found to be above 10° of hardness it will not be suitable for most purposes in bleaching, dyeing, and printing until it has undergone a softening process.

Softening Hard Waters.—There are several methods adopted for softening hard water. Some waters can be made softer by merely boiling them, such waters are said to be temporary hard waters; and the hardness in their case is due to bicarbonates of lime and magnesia. By boiling, the bicarbonates are decomposed, a portion of the carbonic acid being given off leaving the lime and magnesia in the form of insoluble carbonates, a condition in which they do not destroy soap, hence less soap will be required to produce a lather in such waters. But sometimes the hardness of water is due to sulphates or chlorides, in which case boiling will have little or no effect on them, and they are said to be permanently hard waters.

A very simple and cheap method for softening temporary hard water is that known as Clark's process, the principle of which is the conversion of the soluble bicarbonates into the insoluble normal carbonates by the addition of hydrate of lime in the form of a milky liquid. In order to carry out Clark's process satisfactorily, the required quantity of hydrate of lime must be carefully calculated, after a quantitative analysis of the water has been made. After the lime has been added, the water requires to be well settled in order to get clear of the precipitated carbonate of lime and other substances taken

down with it. For this purpose there are specially constructed settling tanks, which are capable of settling a large quantity of water without taking up much room.

Phosphate of soda is a good reagent for softening water, as it will soften both permanent and temporary hard water by removing the lime and magnesia in the form of insoluble phosphates.

THEORY OF COLOURS.

The shades of colour in which the cotton fibre is dyed and printed are almost innumerable, and before stating how these various shades are obtained, I will endeavour to explain somewhat of the nature of colour. In the first place, colour is due to light—where there is no light there is no colour. In the next place, the difference in colours is not due to the quantity or intensity of light—a red colour will appear red whether we see it by a strong or a feeble light. What, then, is the cause of the difference between, say, a red and a blue colour? Well, the difference is due to the fact that there are different colours of light—*i.e.*, red light, blue light, &c. If we look at a piece of red cloth, we see that it is red, because the cloth throws red light into our eyes; in the same way a piece of blue cloth throws blue light into our eyes, and so with other colours. Now these coloured lights do not come originally from the coloured cloth, for if we take the red or blue cloth into a perfectly dark room, no light comes from either of them, and we could not distinguish one from the other; but if we light a lamp in the room we at once see which is the red and which is the blue cloth. Therefore, the light must come from the lamp, fall upon the cloth, and be thrown from the cloth into our eyes. But the light from the lamp is neither red nor blue, but white. Why, then, does the red cloth throw off the red light which falls upon it? Can the red cloth change white light into red light? Suppose we cover our lamp with a blue-glass shade, so that only blue light can get from the lamp and fall upon the pieces of red-, blue-, and yellow-dyed cloth, then it will be seen that only the blue-dyed cloth throws off any light to our eyes; the red and yellow bits appear just the same as if there were no light at all in the room; if we cover the lamp with a red-glass shade, then it is only the bit of red-dyed cloth that can be seen; with a yellow-glass shade over the lamp it is only the yellow-dyed cloth that throws off any light, and so with other colours. In this way it can be shown that a certain coloured cloth (say red, for instance) cannot change the colour of the light that falls upon it, and can only be seen to be red when red light falls upon it. How, then, is it that whatever colour we dye a piece of cloth, we can always see that colour by white light? Because white light consists of all the coloured lights combined together; and when the white light falls upon a coloured cloth—*e.g.*, red—only the red constituent of the white light

is thrown from the red cloth into our eyes. So when we want to dye a piece of white cloth a certain colour, we must charge it with something which will reflect only the particular colour of light which we want the cloth to appear. Let us briefly consider the explanation of colours as usually given in text-books on light. White light is, we read, made up of a number of coloured constituents. According to Sir Isaac Newton there are seven, viz.:—Red, orange, yellow, green, blue, indigo, and violet; but, according to Sir David Brewster, only three—viz., red, yellow, and blue. Whilst according to Helmholtz and most modern physicists, the three primary constituents of white light are red, green, and violet. It is stated in most books on light that if white light falls upon a piece of well bleached cloth, all three constituents of the white light are reflected from the cloth into our eyes, and the cloth appears white. If white light falls upon a piece of charcoal, all three constituents of the white light are absorbed by the charcoal; the charcoal, therefore, appears black, because no light is reflected from it to our eyes. Again, if white light falls upon ultramarine blue, one of the three constituents of white light must be absorbed by the ultramarine, and the other two constituents reflected to our eyes, because, if two of the constituents of white light were absorbed by the ultramarine, it would not appear blue, but either red, green, or violet. For the same reason chrome yellow must reflect two of the three constituents of white light. According to Helmholtz, ultramarine blue reflects green and violet, whilst chrome yellow reflects green and red light; therefore, if we mix ultramarine blue with chrome yellow, the mixture will appear green, not, as so many people suppose, because blue and yellow make green, but because green is the only constituent of white light reflected by both these pigments. If we dye a piece of cloth with alizarine upon an alumina mordant in the ordinary way, the cloth will appear red. If we dye a piece of cloth with alizarine upon an iron mordant, the cloth will appear purple. Again, if we dye a piece of cloth with alizarine upon a mixture of alumina and iron mordant, the cloth will appear chocolate. Now, why does the cloth appear chocolate in the latter case? Is it because both red and purple are reflected from the cloth in this case? No; for red and purple light produce crimson, not chocolate; besides, the cloth does not reflect red and purple, but only red light in this latter case. Why, then, does the cloth not appear red instead of chocolate, as we find it? Well, it is just here where all attempts to explain colours have failed. Suppose we look at a sheet of red-coloured paper, we know well enough why the paper appears red to us; it is because the rays of white light which fall upon the paper have lost two of the three constituents of light, viz., the green and violet, and only one, the red, is reflected into our eyes, and this, acting upon a certain portion of the retina, produces the sensation which we call redness. But suppose we draw a design or pattern

in small black dots upon red paper. Of course, we say we can see the design, although nothing more is reflected from the paper to our eyes after the design is traced on the paper than before; but, rather, there is something less reflected from the paper, for the black dots will absorb some of the red light, and prevent it from entering our eyes. Suppose, now, we increase the complexity of our design in black upon the red paper, by adding more and more small black dots, we shall find that after a time the design will become more and more confused, until, when the black dots become very numerous, we shall lose the design entirely, and, in the meantime, the colour of the paper will have undergone a change, until it acquires a more or less chocolate appearance. If we make the same experiment upon white paper, we shall find it gradually change to grey. Orange paper will, by the same experiment, change to brown, but as the above experiment would be very difficult to carry out practically, a much better plan would be to take pieces of, say, red, green, orange, blue, yellow, &c., cloth, and dye them with a small quantity of direct black.

Now, these colours (chocolate, brown, grey, olive, &c.) are non-spectrum colours; and I say that the production of non-spectrum colours has not been, and cannot be explained, upon any accepted theory of light; yet every colour mixer knows that all such colours can be produced by mixing together in various proportions red, blue, and yellow pigments. But physicists say that mixing pigments is entirely different from the mixing of lights. Well, that must be so, if we can produce many colours—*i.e.*, chocolates, browns, olives, &c.—by mixing pigments, whereas these colours cannot be produced by mixtures of coloured lights. But are the explanations given by physicists for the production of colours by mixtures of pigments correct? I think not. They tell us, for instance, that the production of green by a mixture of blue and yellow pigments is due to the quenching of all except the green rays of light by the mixed pigments; but they tell us also that when light is quenched in this manner black is produced. We have just seen that green and black together give olive. Why, then, does not the mixture of blue and yellow pigments appear olive and not green? Again, how will physicists get over the fact that when we add a small quantity of red to the blue and yellow pigments we do really produce an olive? Physicists tell us that a mixture of red and yellow pigments produces orange, because all rays of light except the orange are quenched by this mixture. Here, of course, we have the same difficulty as before. Why does not the black, produced by the quenching of the other rays, combined with the reflected orange, give a brown appearance, as it would if black were really present? There is a further difficulty in this latter explanation; the orange appearance of a mixture of red and yellow powders cannot be due to the reflected orange rays as, according to the most modern physicists, there are no orange rays of light, but only red, green, and violet.

Since the physicists cannot explain the production of various colours it will, perhaps, be as well to inquire what colour mixers have to say about the matter. Well, most colour mixers who have thought anything at all about the subject would, if asked why a mixture of yellow and blue pigments appear green, reply that it is because we see both pigments at the same time—that is, the blue light from the blue pigment and the yellow light from the yellow pigment both enter our eyes at the same time and produce the appearance of green. If asked why the addition of a small quantity of red pigment to the green mixture caused the latter to change to olive, they would reply that it is the addition of the small quantity of red light from the red pigment, together with the blue and yellow, which gives the appearance of olive. But if further questioned as to why the addition of a larger quantity of red pigment to the green mixture causes the latter to change to black, I think they would nearly all give it up. Now, why do the explanations come to so sudden a stop? Because every one has been taught that black is the absence of all colour, whereas they have just produced it by mixing all the colours together. Now, to be consistent, colour mixers ought to boldly press forward their theory, and say that black is produced when we look at a certain proportion of red, blue, and yellow pigments at the same time; that it is, in fact, the red light from the red pigment, the blue light from the blue pigment, and the yellow light from the yellow pigment, all entering our eyes at the same time which produce the appearance of black. But physicists will object that this is reversing the generally accepted theory of light. Well, why not, if the accepted theory will not explain the facts of the case? We can get a brown by mixing red, yellow, and blue pigments in certain proportions. We can also produce the brown by a judicious mixture of red, yellow, and black pigments. Now, I have already said that the ordinary theory of light is incapable of explaining this production of a brown colour; but by assuming that black instead of being the absence of all colour, is rather the result of seeing all the colours at the same time, it becomes possible to explain the production of brown or any other non-spectrum colour. Suppose we assume (only for the sake of argument) that black consists of 60 parts of red, 80 parts of yellow, and 40 parts of blue. Suppose, in the same way, that orange consists of 60 parts of red and 80 parts of yellow, and that brown consists of 120 parts of red, 160 parts of yellow, and 40 parts of blue; it would then become quite clear why we produce the same brown when we mix 120 parts of red, 160 parts of yellow, and 40 parts of blue, that we get when we mix 60 parts of red, 80 parts of yellow, and 180 parts of black. In the same way we can explain the formation of any other non-spectrum colour (olive, for example). Let us suppose the olive to consist of 80 parts of blue, 160 parts of yellow, and 60 parts of red; it can easily be seen that we could produce the olive by mixing the red, yellow,

and blue together in these proportions, or we could get the same olive by mixing 40 parts of blue, 80 parts of yellow, and 180 parts of black. Now, I know that physicists will object that I am making out black and white to contain the same constituents; but may it not be that the constituents are combined together in one case—white—whereas in the other case—black—they are in a free state. The elements of a compound (chalk, for example) have not the same properties when combined together in the compound that they have when seen together in the free state. Why then may not the primary colours, when seen blended together as they are in white light, have a different appearance to what they have when seen all at once, but in an uncombined state, as we see them when we look at a black object? Whatever may be the explanation of colours theoretically, I think it can be shown that practically we can produce all shades of colours from five elements—viz., red, yellow, blue, black, and white; and as black is produced by a judicious mixture of red, yellow, and blue, and as white is supplied by the cloth itself, our elementary colours are practically limited to three.

The Metric System of Weights and Measures.

The metre, equal to 39·37 English inches, is a standard of linear measure which was supposed to be the ten-millionth part of the distance from the equator to the north pole, as ascertained by actual measurement of an arc of the meridian.

The metrical system, formed on the metre as a unit of length, has four other leading units, all connected with and dependent upon this. Hence we have :—

1. The *metre*, which is the unit of measures of length.
2. The *are*, which is the unit of surface, and is the square of the metre.
3. The *litre*, which is the unit of the measures of capacity, and is the cube of the tenth part of a metre.
4. The *stere*, which is the unit of measures of solidity, having the capacity of a cubic metre.
5. The *gramme*, which is the unit of measures of weight, and is the weight of that quantity of distilled water at its maximum density which fills the cube of the hundredth part of a metre.

Each unit has its decimal multiples and submultiples—that is, weights and measures ten times larger, or ten times smaller, than the principal units. The prefixes denoting multiples are derived from the Greek, and are—deka, ten; hecto, hundred; kilo, thousand; and myria, ten thousand. Those denoting submultiples are taken from the Latin, and are—deci, a tenth; centi, an hundredth; and milli, a thousandth.

The metric system has been adopted by many nations, the English excepted. All formulæ received from the Continent of Europe express values and quantities with metrical weights and measures; to utilise them directly, without translation into the expressions of the English system, the student is advised to procure gramme weights and cubic centimetre measures, and substitute them for those denoting quantities according to the old plan. As an assistance to those who cannot acquire those aids, we annex tables which convert grammes and cubic centimetres into English grains, drams, and ounces with sufficient correctness for practical purposes.

The cubic centimetre, usually represented by "c.c.," is the smaller unit of the metric measurement for liquids. It is the thousandth part of a litre, and contains

nearly 17 minims of water; in reality it contains 16·90 minims. The weight of this quantity of distilled water, at its greatest density, 4° C., is 1 gramme. The following table is sufficiently accurate for practical purposes:—

THE CONVERSION OF FRENCH (METRIC) INTO ENGLISH MEASURE.

1	cubic centimetre	=	17	minims.						
2	cubic centimetres	=	34	,,						
3	,,	=	51	,,						
4	,,	=	68	,,	or	1	dram	8	minims.	
5	,,	=	85	,,	,,	1	,,	25	,,	
6	,,	=	102	,,	,,	1	,,	42	,,	
7	,,	=	119	,,	,,	1	,,	59	,,	
8	,,	=	136	,,	,,	2	drams	16	,,	
9	,,	=	153	,,	,,	2	,,	33	,,	
10	,,	=	170	,,	,,	2	,,	50	,,	
20	,,	=	340	,,	,,	5	,,	40	,,	
30	,,	=	510	,,	,,	1	ounce	0	dram	30 minims.
40	,,	=	680	,,	,,	1	,,	3	drams	20 ,,
50	,,	=	850	,,	,,	1	,,	6	,,	10 ,,
60	,,	=	1020	,,	,,	2	ounces	1	,,	0 ,,
70	,,	=	1190	,,	,,	2	,,	3	,,	50 ,,
80	,,	=	1360	,,	,,	2	,,	6	,,	40 ,,
90	,,	=	1530	,,	,,	3	,,	1	,,	30 ,,
100	,,	=	1700	,,	,,	3	,,	4	,,	20 ,,
1000	,,	=	1 litre	=	36	fluid	ounces	nearly,	or	$1\frac{4}{5}$ pints.

THE CONVERSION OF FRENCH (METRIC) INTO ENGLISH WEIGHT.

Although a gramme is equal to 15·4346 grains, the decimal is one which cannot conveniently be used; hence in the following table it is assumed to be $15\frac{2}{5}$ grains, which is a near approach to *practical* accuracy:—

1	gramme	=	$15\frac{2}{5}$	grains.						
2	grammes	=	$30\frac{4}{5}$	,,						
3	,,	=	$46\frac{1}{5}$	,,						
4	,,	=	$61\frac{3}{5}$	,,	. . .	or	1	dram	$1\frac{3}{5}$	grain.
5	,,	=	77	,,	. . .	,,	1	,,	17	grains.
6	,,	=	$92\frac{2}{5}$	,,	. . .	,,	1	,,	$32\frac{2}{5}$	,,
7	,,	=	$107\frac{4}{5}$	,,	. . .	,,	1	,,	$47\frac{4}{5}$	,,
8	,,	=	$123\frac{1}{5}$	,,	. . .	,,	2	drams	$3\frac{1}{5}$	,,
9	,,	=	$138\frac{3}{5}$	,,	. . .	,,	2	,,	$18\frac{3}{5}$	,,
10	,,	=	154	,,	. . .	,,	2	,,	34	,,
11	,,	=	$169\frac{2}{5}$	,,	. . .	,,	2	,,	$49\frac{2}{5}$	,,
12	,,	=	$184\frac{4}{5}$	,,	. . .	,,	3	,,	$4\frac{4}{5}$	,,
13	,,	=	$200\frac{1}{5}$	,,	. . .	,,	3	,,	$20\frac{1}{5}$	,,
14	,,	=	$215\frac{3}{5}$	,,	. . .	,,	3	,,	$35\frac{3}{5}$	,,
15	,,	=	231	,,	. . .	,,	3	,,	51	,,
16	,,	=	$246\frac{2}{5}$	,,	. . .	,,	4	,,	$6\frac{2}{5}$	,,
17	,,	=	$261\frac{4}{5}$	,,	. . .	,,	4	,,	$21\frac{4}{5}$	,,
18	,,	=	$277\frac{1}{5}$	,,	. . .	,,	4	,,	$37\frac{1}{5}$	,,
19	,,	=	$292\frac{3}{5}$	,,	. . .	,,	4	,,	$52\frac{3}{5}$	,,
20	,,	=	308	,,	. . .	,,	5	,,	8	,,
30	,,	=	462	,,	. . .	,,	7	,,	42	,,
40	,,	=	616	,,	. . .	,,	10	,,	16	,,
50	,,	=	770	,,	. . .	,,	12	,,	50	,,
60	,,	=	924	,,	. . .	,,	15	,,	24	,,
70	,,	=	1078	,,	. . .	,,	17	,,	58	,,

80 grammes	=	1232 grains,	. . .	or 20 drams 32 grains.
90 ,,	=	1386 ,,	. . .	,, 23 ,, 6 ,,
100 ,,	=	1540 ,,	. . .	,, 25 ,, 40 ,,
1000 ,,	=	1 kilogramme	=	32 ounces 0 drams 40 grains (apoth. wt.)
1000 ,,	=	1 ,,	=	$35\frac{1}{3}$ ounces (avoir. wt.)

Thermometric Tables,

Showing the relation of the three thermometric scales most in use throughout the world.

Celsius.	Reaumur.	Fahrenheit.	Celsius.	Reaumur.	Fahrenheit.
100	80·0	212·0	49	39·2	120·2
99	79·2	210·2	48	38·4	118·4
98	78·4	208·4	47	37·6	116·6
97	77·6	206·6	46	36·8	114·8
96	76·8	204·8	45	36·0	113·0
95	76·0	203·0	44	35·2	111·2
94	75·2	201·2	43	34·4	109·4
93	74·4	199·4	42	33·6	107·6
92	73·6	197·6	41	32·8	105·8
91	72·8	195·8	40	32·0	104·0
90	72·0	194·0	39	31·2	102·2
89	71·2	192·2	38	30·4	100·4
88	70·4	190·4	37	29·6	98·6
87	69·6	188·6	36	28·8	96·8
86	68·8	186·8	35	28·0	95·0
85	68·0	185·0	34	27·2	93·2
84	67·2	183·2	33	26·4	91·4
83	66·4	181·4	32	25·6	89·6
82	65·6	179·6	31	24·8	87·8
81	64·8	177·8	30	24·0	86·0
80	64·0	176·0	29	23·2	84·2
79	63·2	174·2	28	22·4	82·4
78	62·4	172·4	27	21·6	80·6
77	61·6	170·6	26	20·8	78·8
76	60·8	168·8	25	20·0	77·0
75	60·0	167·0	24	19·2	75·2
74	59·2	165·2	23	18·4	73·4
73	58·4	163·4	22	17·6	71·6
72	57·6	161·6	21	16·8	69·8
71	56·8	159·8	20	16·0	68·0
70	56·0	158·0	19	15·2	66·2
69	55·2	156·2	18	14·4	64·4
68	54·4	154·4	17	13·6	62·6
67	53·6	152·6	16	12·8	60·8
66	52·8	150·8	15	12·0	59·0
65	52·0	149·0	14	11·2	57·2
64	51·2	147·2	13	10·4	55·4
63	50·4	145·4	12	9·6	53·6
62	49·6	143·6	11	8·8	51·8
61	48·8	141·8	10	8·0	50·0
60	48·0	140·0	9	7·2	48·2
59	47·2	138·2	8	6·4	46·4
58	46·4	136·4	7	5·6	44·6
57	45·6	134·6	6	4·8	42·8
56	44·8	132·8	5	4·0	41·0
55	44·0	131·0	4	3·2	39 2
54	43·2	129·2	3	2·4	37·4
53	42·4	127·4	2	1·6	36·5
52	41·6	125·6	1	0·8	33·8
51	40·8	123·8	0	0·0	32·0
50	40·0	122·0			

To convert Centigrade (Celsius) into Fahrenheit, if the temperature be above the freezing point of water (and lower temperatures do not occur in dyeing and printing processes), multiply by 9, divide the product by 5, and add 32 to the quotient.

To convert degrees of Fahrenheit above the freezing point into Centigrade, subtract 32, multiply the remainder by 5, and divide the product by 9.

To convert Reaumur into Fahrenheit, multiply by 9, divide by 4, and add 32 to the quotient.

To convert Fahrenheit into Reaumur, subtract 32, multiply the remainder by 4, and divide the product by 9.

COMPARATIVE HYDROMETER SCALE.

Specific gravity, Beaumé and Twaddel.

Specific Gravity.	Degrees Beaumé.	Degrees Twaddel.	Specific Gravity.	Degrees Beaumé.	Degrees Twaddel.
1·000	0	0	1·221	26	44·2
1·007	1	1·4	1·231	27	46·2
1·014	2	2·8	1·242	28	48·4
1·022	3	4·4	1·252	29	50·4
1·029	4	5·8	1·261	30	52·2
1 036	5	7·2	1·275	31	55·0
1·044	6	8·8	1·286	32	57·2
1·052	7	10·4	1·298	33	59·6
1·060	8	12·0	1·309	34	61·8
1·067	9	13·4	1·321	35	64·2
1·075	10	15·0	1·334	36	66·8
1·083	11	16·6	1·346	37	69·2
1·091	12	18·2	1·359	38	71·8
1·100	13	20·0	1·372	39	74·4
1·108	14	21·6	1·384	40	76·8
1·116	15	23·2	1·398	41	79·6
1·125	16	25·0	1·412	42	82·4
1·134	17	26·8	1·426	43	85·2
1·143	18	28·6	1·440	44	88·0
1·152	19	30·4	1·454	45	90·8
1·161	20	32·2	1·470	46	94 0
1·171	21	34·2	1·485	47	97·0
1·180	22	36·0	1·501	48	100·2
1·190	23	38·0	1·516	49	103·2
1·199	24	39·0	1·532	50	106·4
1·210	25	42·0			

To convert Twaddel into specific gravity, multiply by 5, considering the product as decimals, and add to it 1·000. Thus, if a sample of soda solution marks 59° Tw., we have—

59
5
·295
1·000
1·295 = the specific gravity of the solution.

On the other hand, if the strength of the solution has been taken by direct specific gravity, we find the degree Twaddel by subtracting 1·000 and dividing the remainder by 5, thus—

1·295
1·000
5 | 295
59° Twaddel.

TABLE SHOWING THE PERCENTAGES OF REAL SULPHURIC ACID (SO_4H_2) CORRESPONDING TO VARIOUS SPECIFIC GRAVITIES OF AQUEOUS SULPHURIC ACID.

Bineau; Otto. Temp. 15°.

Specific gravity.	Per cent.	Specific gravity.	Per cent.	Specific gravity.	Per cent.	Specific gravity.	Per cent.
1·8426	100	1·675	75	1·398	50	1·182	25
1·842	99	1·663	74	1·3886	49	1·174	24
1·8406	98	1·651	73	1·379	48	1·167	23
1·840	97	1·639	72	1·370	47	1·159	22
1·8384	96	1·627	71	1·361	46	1·1516	21
1·8376	95	1·615	70	1·351	45	1·144	20
1·8356	94	1·604	69	1·342	44	1·136	19
1·834	93	1·592	68	1·333	43	1·129	18
1·831	92	1·580	67	1·324	42	1·121	17
1·827	91	1·568	66	1·315	41	1·1136	16
1·822	90	1·557	65	1·306	40	1·106	15
1·816	89	1·545	64	1·2976	39	1·098	14
1·809	88	1·534	63	1·289	38	1·091	13
1·802	87	1·523	62	1·281	37	1·083	12
1·794	86	1·512	61	1·272	36	1·0756	11
1·786	85	1·501	60	1·264	35	1·068	10
1·777	84	1·490	59	1·256	34	1·061	9
1·767	83	1·480	58	1·2476	33	1·0536	8
1·756	82	1·469	57	1·239	32	1·0464	7
1·745	81	1·4586	56	1·231	31	1·039	6
1·734	80	1·448	55	1·223	30	1·032	5
1·722	79	1·438	54	1·215	29	1·0256	4
1·710	78	1·428	53	1·2066	28	1·019	3
1·698	77	1·418	52	1·198	27	1·013	2
1·686	76	1·408	51	1·190	26	1·0064	1

TABLE GIVING THE PERCENTAGE AMOUNT OF HYDROCHLORIC ACID CONTAINED IN AQUEOUS SOLUTIONS OF THE GAS OF VARIOUS SPECIFIC GRAVITIES.

Ure. Temp. 15°

Specific Gravity.	HCl per cent.	Specific gravity.	HCl per cent.	Specific gravity.	HCl per cent.	Specific gravity.	HCl per cent.
1·2000	40·777	1·1515	30·582	1·1000	20·388	1·0497	10·194
1·1982	40·369	1·1494	30·174	1·0980	19·980	1·0477	9·786
1·1964	39·961	1·1473	29·767	1·0960	19·572	1·0457	9·379
1·1946	39·554	1·1452	29·359	1·0939	19·165	1·0437	8·971
1·1928	39·146	1·1431	28·951	1·0919	18·757	1·0417	8·563
1·1910	38·738	1·1410	28·544	1·0899	18·349	1·0397	8·155
1·1893	38·330	1·1389	28·136	1·0879	17·941	1·0377	7·747
1·1875	37·923	1·1369	27·728	1·0859	17·534	1·0357	7·340
1·1857	37·516	1·1349	27·321	1·0838	17·126	1·0337	6·932
1·1846	37·108	1·1328	26·913	1·0818	16·718	1·0318	6·524
1·1822	36·700	1·1308	26·505	1·0798	16·310	1·0298	6·116
1·1802	36·292	1·1287	26·098	1·0778	15·902	1·0279	5·709
1·1782	35·884	1·1267	25·690	1·0758	15·494	1·0259	5·301
1·1762	35·476	1·1247	25·282	1·0738	15·087	1·0239	4·893
1·1741	35·068	1·1226	24·874	1·0718	14·679	1·0220	4·486
1·1721	34·660	1·1206	24·466	1·0697	14·271	1·0200	4·078
1·1701	34·252	1·1185	24·058	1·0677	13·863	1·0180	3·670
1·1681	33·845	1·1164	23·650	1·0657	13·456	1·0160	3·262
1·1661	33·437	1·1143	23·242	1·0637	13·049	1·0140	2·854
1·1641	33·029	1·1123	22·834	1·0617	12·641	1·0120	2·447
1·1620	32·621	1·1102	22·426	1·0597	12·233	1·0100	2·039
1·1599	32·213	1·1082	22·019	1·0577	11·825	1·0080	1·631
1·1578	31·805	1·1061	21·611	1·0557	11·418	1·0060	1·124
1·1557	31·398	1·1041	21·203	1·0537	11·010	1·0040	0·816
1·1536	30·990	1·1020	20·796	1·0517	10·602	1·0020	0·408

TABLE SHOWING PERCENTAGE AMOUNT OF SODA (Na_2O) IN AQUEOUS SOLUTIONS OF VARIOUS SPECIFIC GRAVITIES.

Tünnermann.

Sp. gr.	Per cent.	Sp. gr.	Per cent.	Sp. gr.	Per cent.	Sp. gr.	Per cent.
1·4285	30·220	1·3198	22·363	1·2392	15·110	1·1042	7·253
1·4193	29·616	1·3143	21·894	1·2280	14·500	1·0948	6·648
1·4101	29·011	1·3125	21·758	1·2178	13·901	1·0855	6·044
1·4011	28·407	1·3053	21·154	1·2058	13·297	1·0764	5·440
1·3923	27·802	1·2982	20·550	1·1948	12·692	1·0675	4·835
1·3836	27·200	1·2912	19·945	1·1841	12·088	1·0587	4·231
1·3751	26·594	1·2843	19·341	1·1734	11·484	1·0500	3·626
1·3668	25·989	1·2775	18·730	1·1630	10·879	1·0414	3·022
1·3586	25·385	1·2708	18·132	1·1528	10·275	1·0330	2·418
1·3505	24·780	1·2642	17·528	1·1428	9·670	1·0246	1·813
1·3426	24·176	1·2578	16·923	1·1330	9·066	1·0163	1·209
1·3349	23·572	1·2515	16·379	1·1233	8·462	1·0081	0·604
1·3273	22·967	1·2453	15·714	1·1137	7·857	1·0040	0·302

TABLE SHOWING THE PERCENTAGE AMOUNT OF AMMONIA IN AQUEOUS SOLUTIONS OF THE GAS OF VARIOUS SPECIFIC GRAVITIES.

Carius. Temp. 14°.

Specific Gravity.	NH_3 per cent.	Specific Gravity.	NH_3 per cent.	Specific Gravity.	NH_3 per cent.
0·8844	36	0·9133	24	0·9520	12
0·8864	35	0·9162	23	0·9556	11
0·8885	34	0·9191	22	0·9593	10
0·8907	33	0·9221	21	0·9631	9
0·8929	32	0 9251	20	0·9670	8
0·8953	31	0·9283	19	0·9709	7
0·8976	30	0·9314	18	0·9749	6
0·9001	29	0·9347	17	0·9790	5
0·9026	28	0·9380	16	0·9831	4
0·9052	27	0·9414	15	0·9873	3
0·9078	26	0·9449	14	0·9915	2
0·9106	25	0·9484	13	0·9959	1

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APPENDIX.

ADDITIONAL RECIPES.

The following are a few examples of the one dip method of dyeing, that is, all the materials, dyestuffs, mordants, &c., being together in one bath. These are best done on the padding mangle and dried by *hot air*:—

No. 34.—Bordeaux Shade.

Cold water, ...	16 gallons.
Ammonia, 950 specific gravity, .	1 gallon.
Oleine oil, 50 per cent., . .	1 ,,
Alizarine Bordeaux, . . .	1 ,, (Bayer & Co.)
Acetate of chrome, 32° Tw., .	½ ,,

No. 35.—Dark Plum Shade.

Cold water, ...	16 gallons.
Ammonia, 950 specific gravity, .	1 gallon.
Oleine oil, 50 per cent., . .	1 ,,
Alizarine cyanine, . . .	1 ,, (Bayer & Co.)
Acetate of chrome, 32° Tw., .	½ ,,

If the above are for plain shades, they must be steamed for 1 hour; wash after, but not before, steaming. If the goods are to be printed in a discharge colour, as below, they must be printed before steaming.

No. 117.—Yellow Discharge on 1 Dip Dyes.

(As above.)

(*a*) 1¼ lbs. chrysophenine.
2 gallons water.
2½ lbs. wheat starch. Boil and stir till cold.

(*b*) 2 gallons water.
8 lbs. chlorate of soda.
25 ozs. citric acid.
34 ozs. red prussiate of potash.
16 lbs. British gum. Boil and stir till cold.

Then add (*b*) to (*a*).

Print on cloth dyed by the 1 dip method, steam 1 hour, wash and dry.

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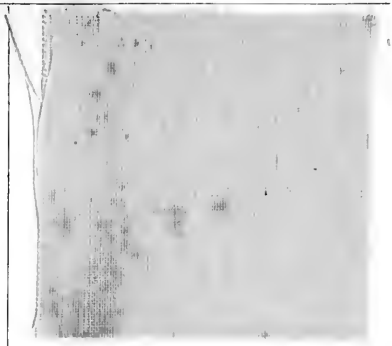
Zinc white, 96.

BELL AND BAIN, LIMITED, PRINTERS, 41 MITCHELL STREET, GLASGOW.

PATTERN SHEET No. 1.

Cloth as received at the works.

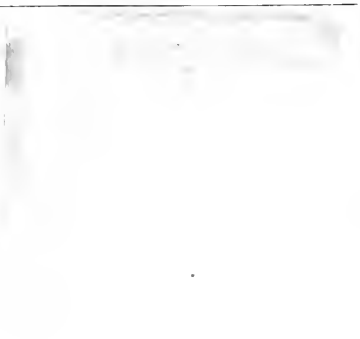


(See p. 6.)
First process in bleaching—Singed.

(See p. 6.)
Second process in bleaching—Lime boiled.

(See p. 10.)
Third process in bleaching—Soured.

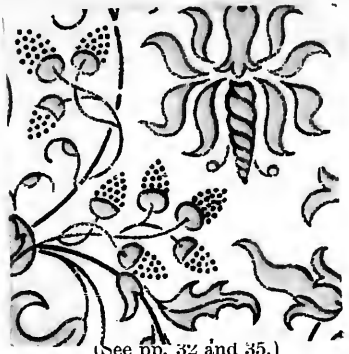
(See p. 11.)
Fourth process in bleaching—First Ash boil.



(See p. 12.)
Fifth process in bleaching—Second Ash boil.

PATTERN SHEET No. 2.

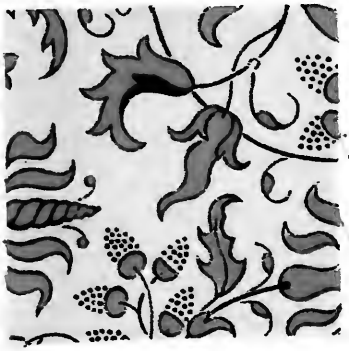
(See p. 12.)
Completely bleached cloth.



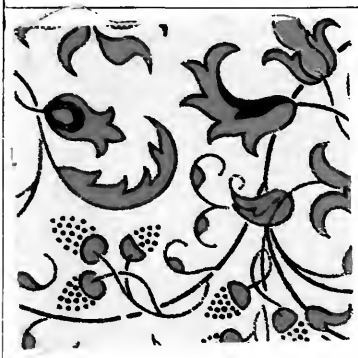
(See pp. 32 and 35.)
No. 1.—First process for dyed red and aniline black—Printed.

(See p. 39.)
No. 1A.—Second process—Dunged and washed.

(See p. 39.)
No. 1B.—Third process—Dyed and washed.

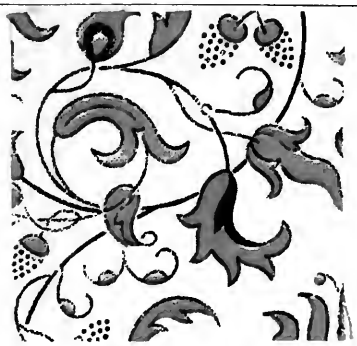


(See p. 40.)
No. 1C.—Fourth process—Oiled and steamed.

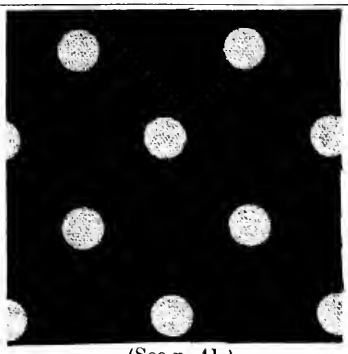


(See p. 40.)
No. 1D.—Fifth process—Soaped.

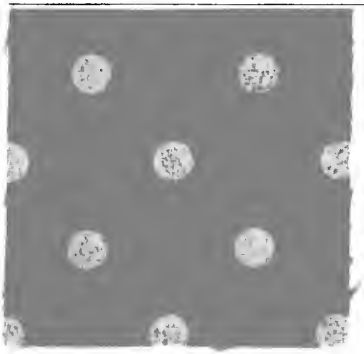
PATTERN SHEET No. 3.



(See p. 41.)
No. 1E.—Sixth process—Chemicked and finished.

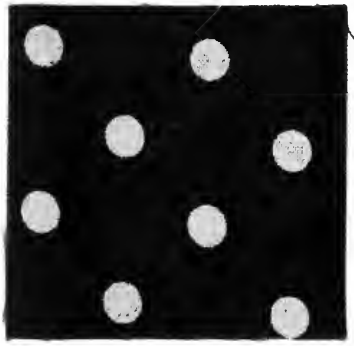


(See p. 41.)
No. 8A.—Alizarine dye on Choc. mordant.

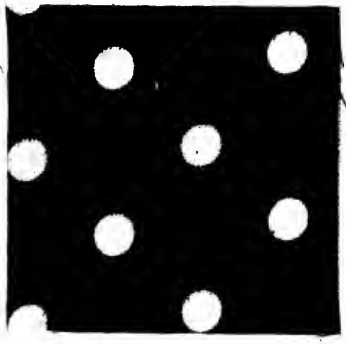


(See p. 41.)
No. 8B.—Alizarine orange dye on 8 Red mordant.

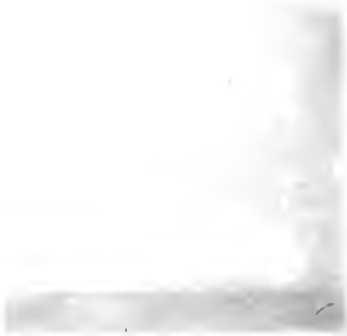
(See p. 41.)
No. 8.—Alizarine dye on 8 Red mordant.



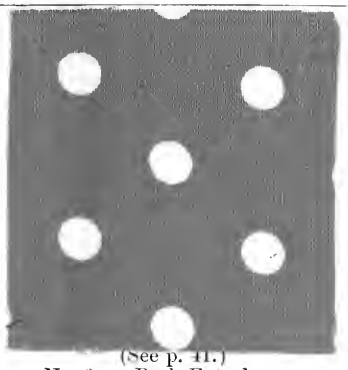
(See p. 41.)
No. 8C.—Alizarine orange dye on Choc. mordant.



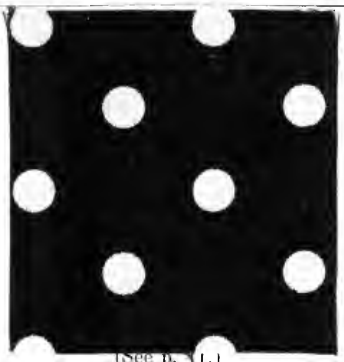
(See p. 41.)
No. 8F.—Cœruleine dye on 8 Red mordant.



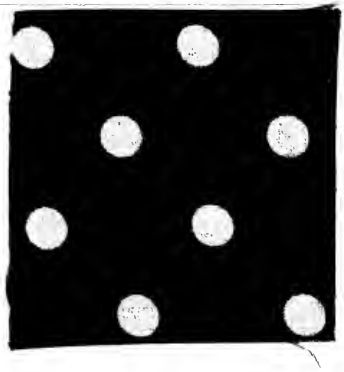
PATTERN SHEET No. 4.



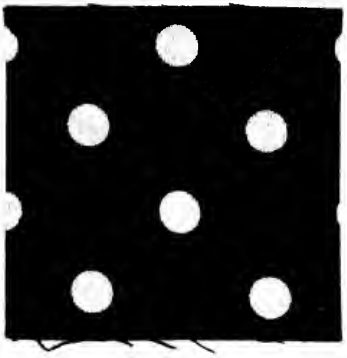
(See p. 41.)
No. 8D.—Bark Ext. dye on 8 Red mordant.



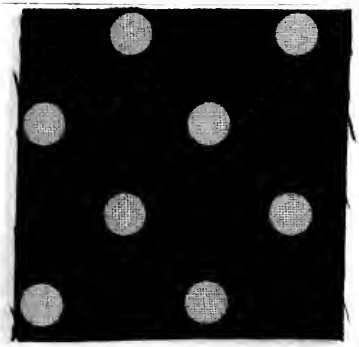
(See p. 41.)
No. 8E.—Bark Ext. dye on Choc. mordant.



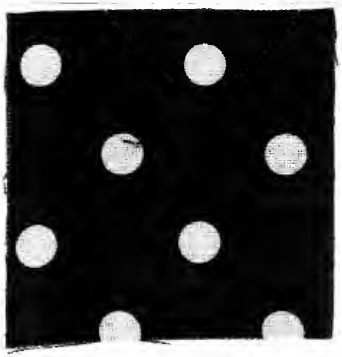
No. 8G.—Cœruleine dye on Choc. mordant.



(See p. 42.)
No. 11.—Resist for Aniline black.

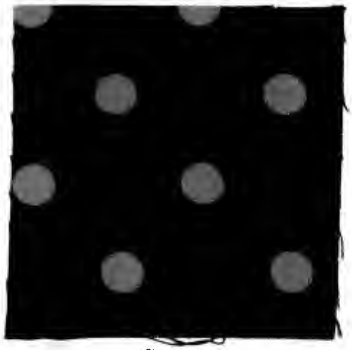


(See p. 43.)
No. 17.—Dark indigo discharge.

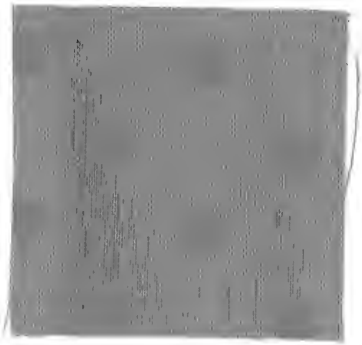


(See p. 43.)
No. 17A.—Light indigo discharge.

PATTERN SHEET No. 5.



(See p. 47.)
No. 29.—Yellow discharge.



(See p. 47.)
No. 29.—Yellow discharge.

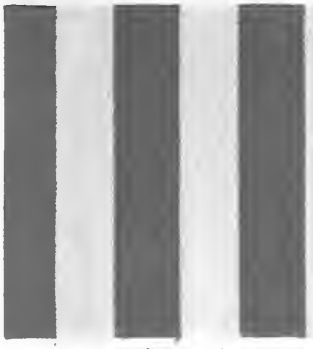
(See p. 47.)
No. 31.—Brown discharge.

(See p. 122.)
No. 25.—Cream pad.

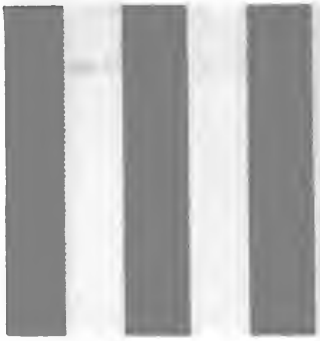
(See Appendix.)
No. 117.—Yellow discharge on Bordeaux shade.

(See Appendix.)
No. 11.—Yellow discharge on Plum shade.

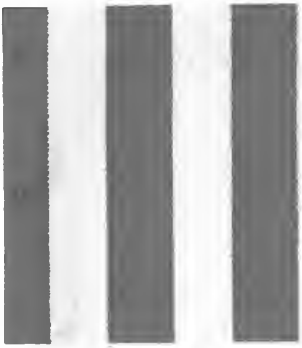
PATTERN SHEET No. 6.



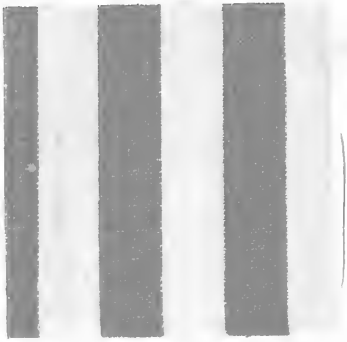
(See p. 49.)
No. 32.



(See p. 49.)
No. 32 reduced 4 Lt. (light).

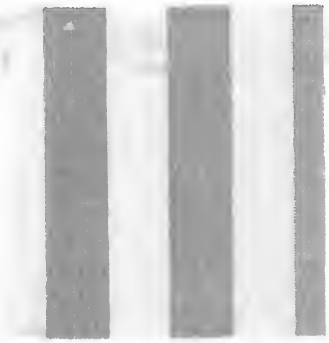


(See p. 49.)
No. 34.



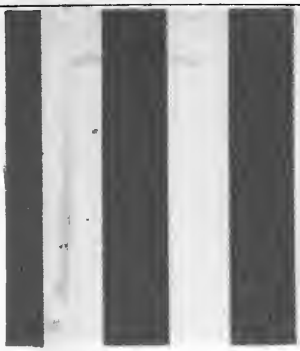
(See p. 49.)
No. 34 reduced 4 Lt.

(See p. 50.)
No. 35.

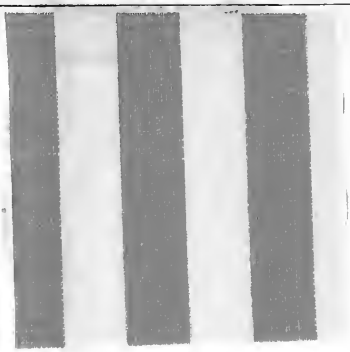


(See p. 50.)
No. 35 reduced 4 Lt.

PATTERN SHEET No. 7.

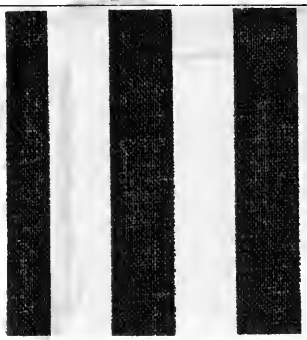


(See p. 50.)
No. 36.

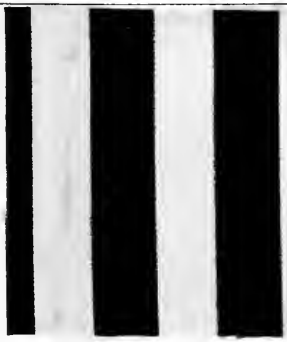


(See p. 50.)
No. 36 reduced 4 Lt. (light).

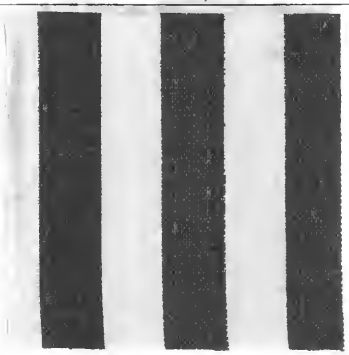
(See p. 50.)
No. 37.



(See p. 50.)
No. 37 reduced 4 Lt.



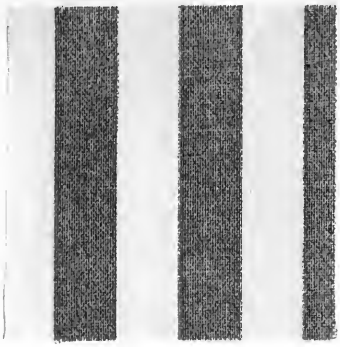
(See p. 51.)
No. 38.



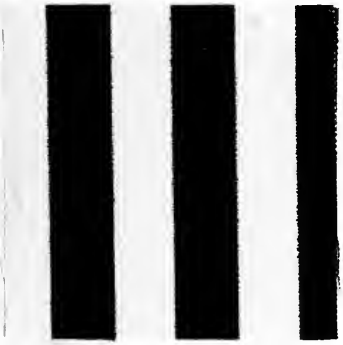
(See p. 51.)
No. 38 reduced 4 Lt.

PATTERN SHEET No. 8.

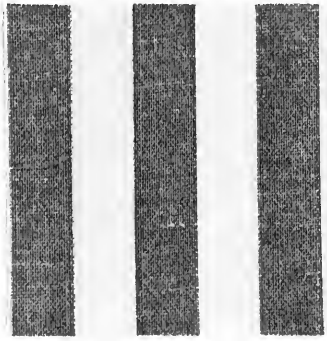
(See p. 51.)
No. 39.



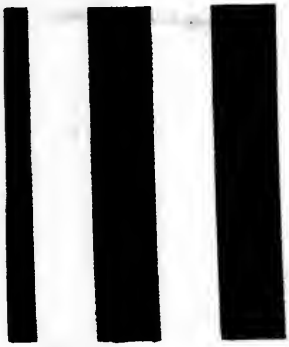
(See p. 51.)
No. 39 reduced 4 Lt. (light).



(See p. 51.)
No. 40.

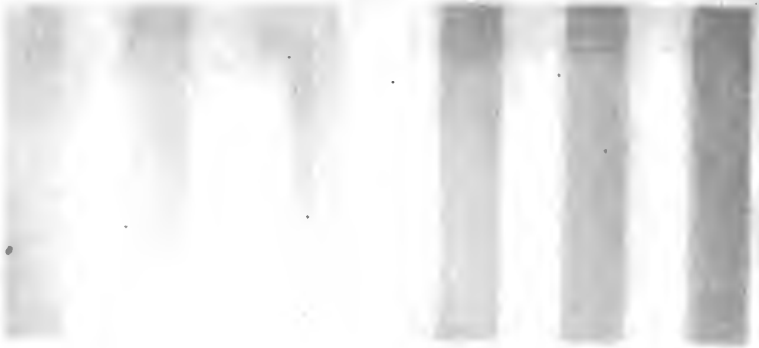


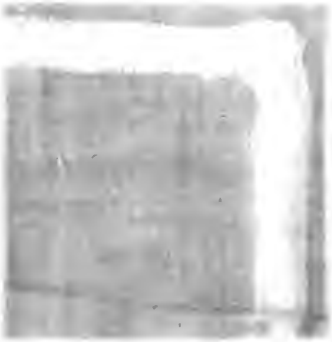
(See p. 51.)
No. 40 reduced 4 Lt.



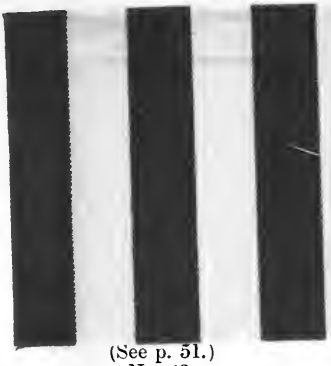
(See p. 51.)
No. 41.

(See Appendix.)
No. 34.—One dip dye.

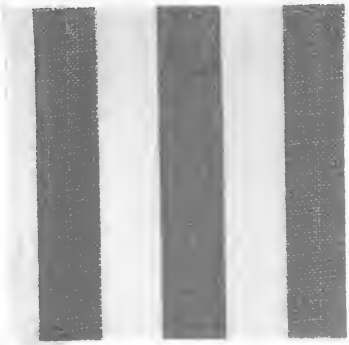




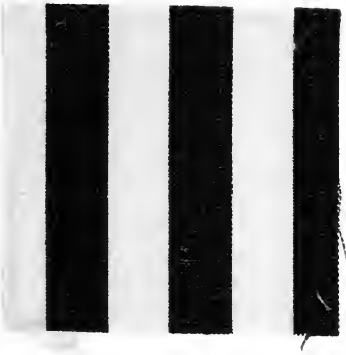
PATTERN SHEET No. 9.



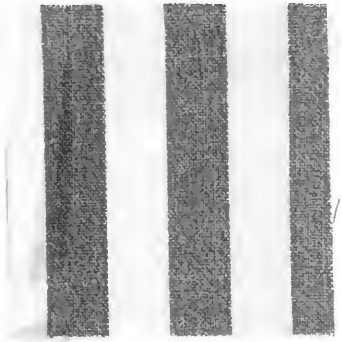
(See p. 51.)
No. 43.



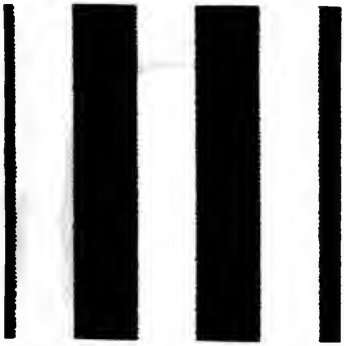
(See p. 51.)
No. 43 reduced 4 Lt. (light).



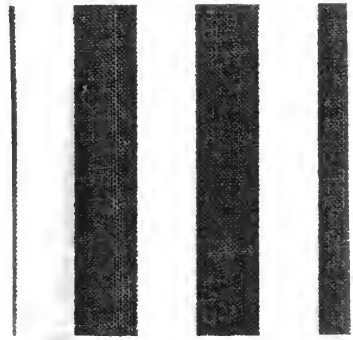
(See p. 52.)
No. 46.



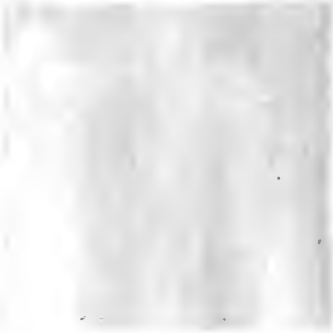
(See p. 52.)
No. 46 reduced 4 Lt.



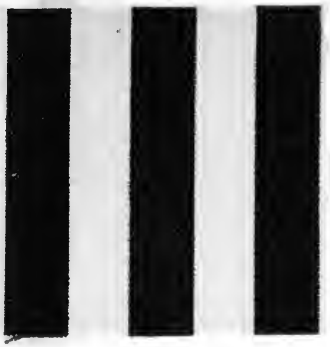
(See p. 52.)
No. 48.



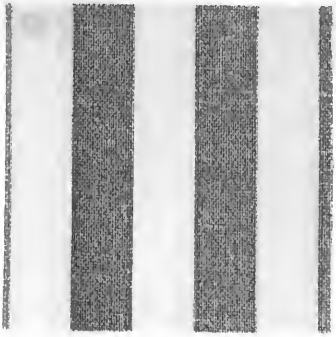
(See p. 52.)
No. 48 reduced 4 Lt.



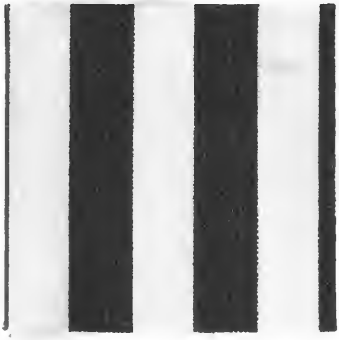
PATTERN SHEET No. 10.



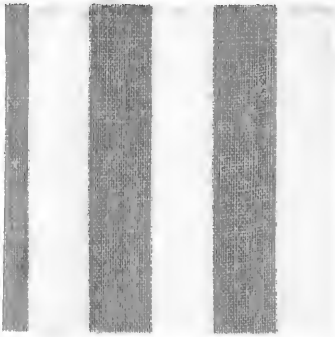
(See p. 52.)
No. 49.



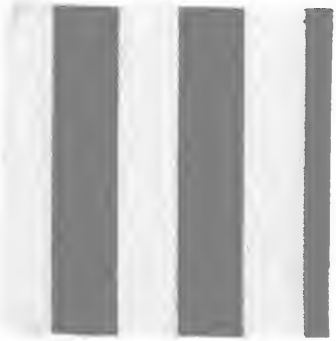
(See p. 52.)
No. 49 reduced 4 Lt. (light).



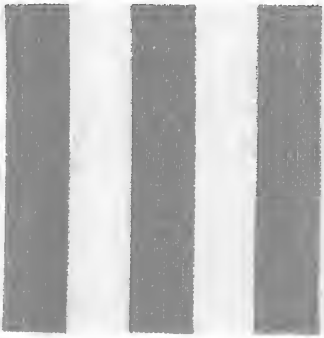
(See p. 52.)
No. 50.



(See p. 52.)
No. 50 reduced 4 Lt.

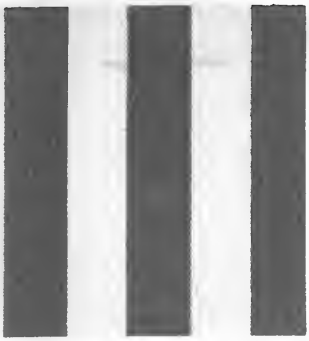


(See p. 52.)
No. 51.



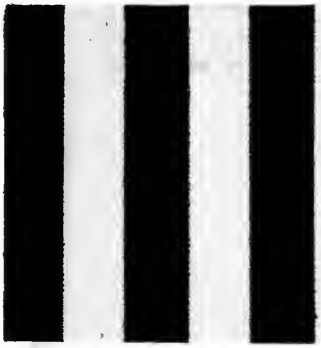
(See p. 52.)
No. 51 reduced 4 Lt.

PATTERN SHEET No. 11.

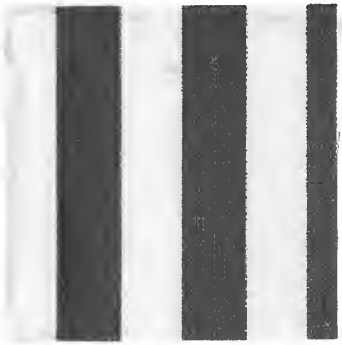


(See p. 52.)
No. 52.

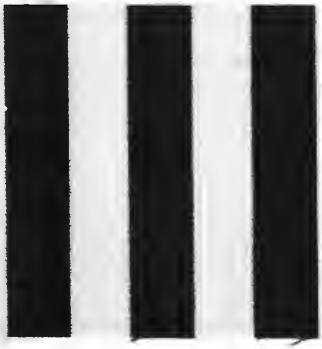
(See p. 52.)
No. 52 reduced 4 Lt. (light).



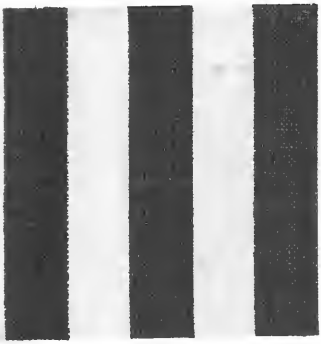
(See p. 52.)
No. 53.



(See p. 52.)
No. 53 reduced 4 Lt.

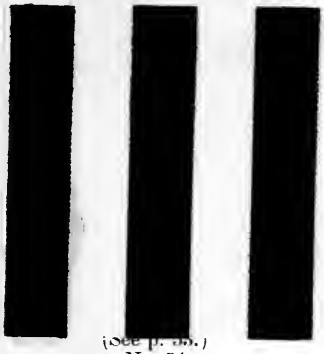


(See p. 67.)
No. 111.

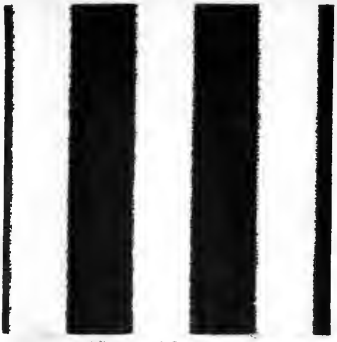


(See p. 67.)
No. 111 reduced 4 Lt.

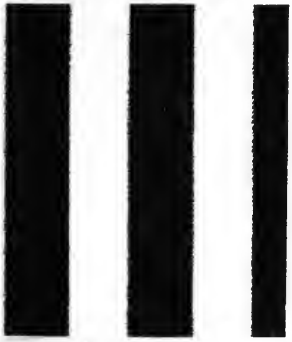
PATTERN SHEET No. 12.



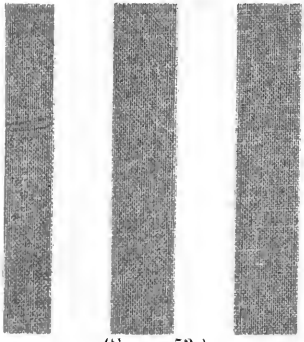
(See p. 53.)
No. 54.



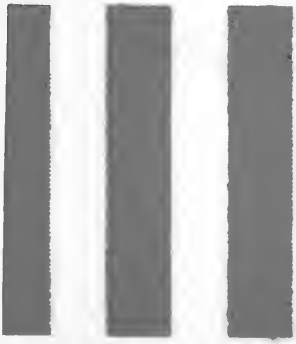
(See p. 53.)
No. 54 reduced 4 Lt. (light).



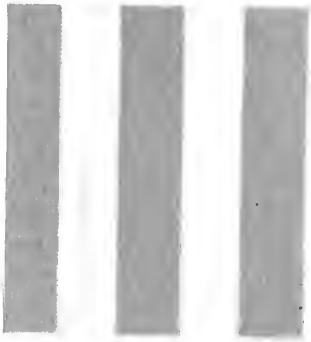
(See p. 53.)
No. 56.



(See p. 53.)
No. 56 reduced 4 Lt.

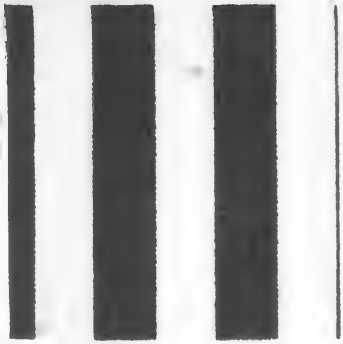


(See p. 53.)
No. 57.

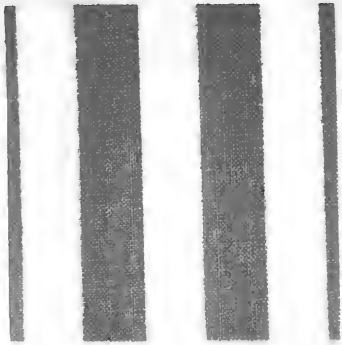


(See p. 53.)
No. 57 reduced 4 Lt.

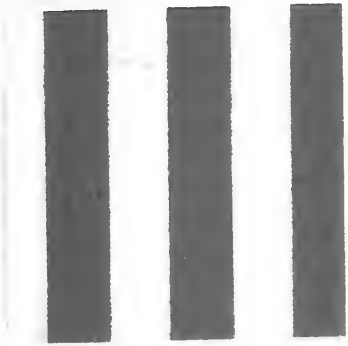
PATTERN SHEET No. 13.



(See p. 54.)
No. 58.

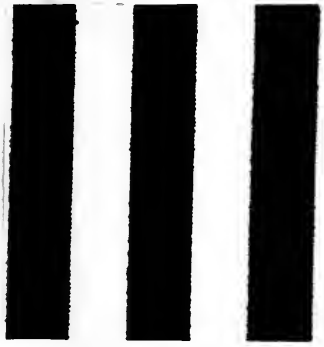


(See p. 54.)
No. 58 reduced 4 Lt. (light).

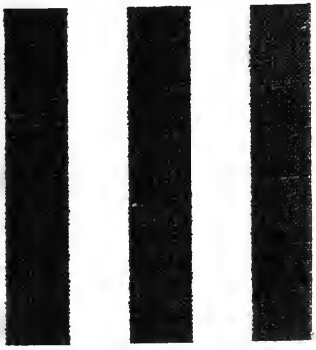


(See p. 54.)
No. 59.

(See Appendix.)
No. 35.—One dip dye.

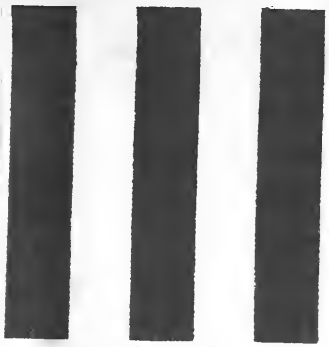


(See p. 54.)
No. 60.

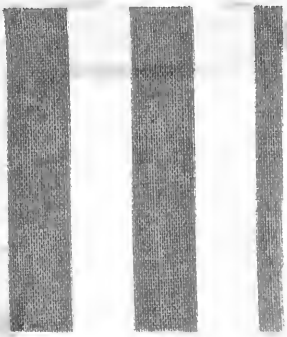


(See p. 54.)
No. 60 reduced 4 Lt.

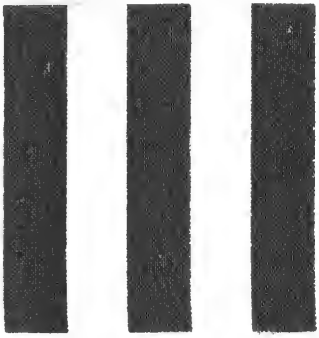
PATTERN SHEET No. 14.



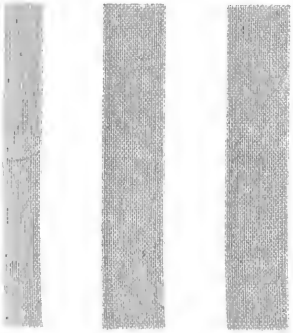
(See p. 55.)
No. 61 reduced 1 Lt. (light).



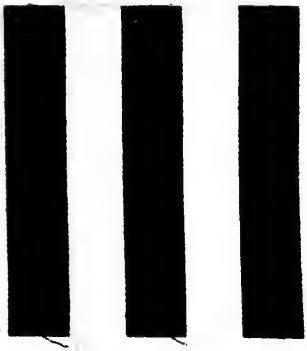
(See p. 55.)
No. 61 reduced 9 Lt.



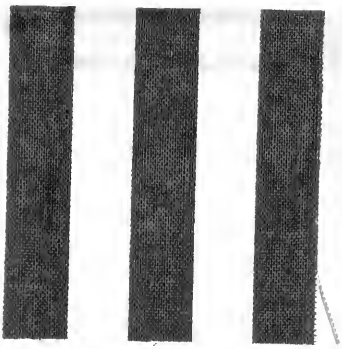
(See p. 55.)
No. 62.



(See p. 55.)
No. 62 reduced 4 Lt.

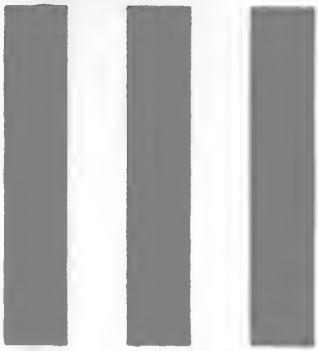


(See p. 56.)
No. 63.

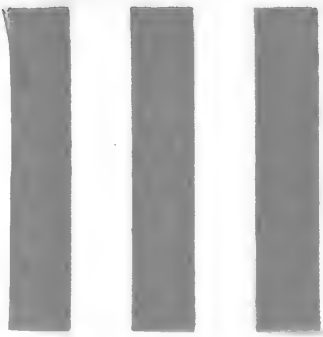


(See p. 56.)
No. 63 reduced 4 Lt.

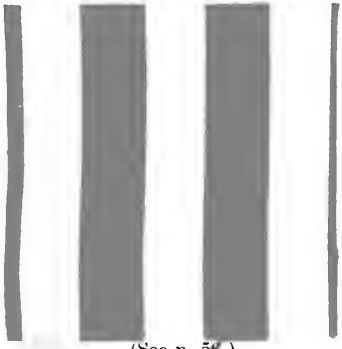
PATTERN SHEET No. 15.



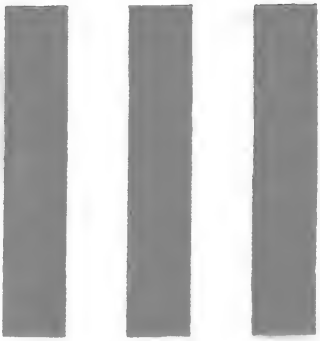
(See p. 56.)
No. 64.



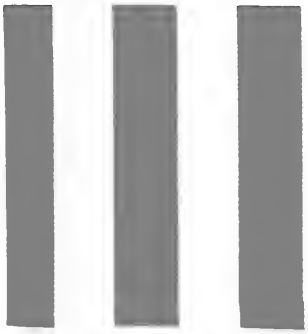
(See p. 56.)
No. 64 reduced 4 Lt. (light).



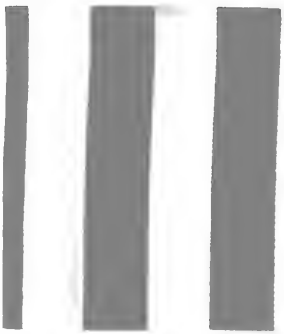
(See p. 56.)
No. 64*x* is { 3 parts of 64.
1 part of 65.



(See p. 56.)
No. 64*x* reduced 4 Lt.

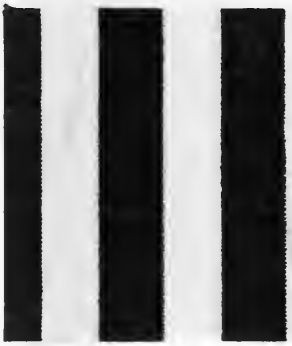


(See p. 56.)
No. 65.

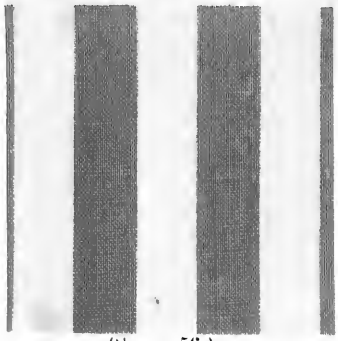


(See p. 56.)
No. 65 reduced 4 Lt.

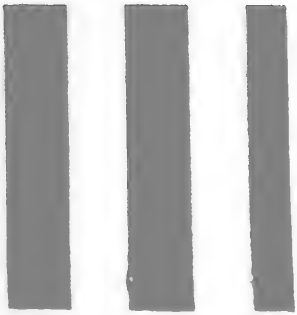
PATTERN SHEET No. 16.



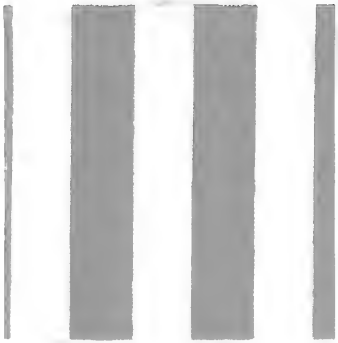
(See p. 56.)
No. 66 reduced 1 Lt. (light).



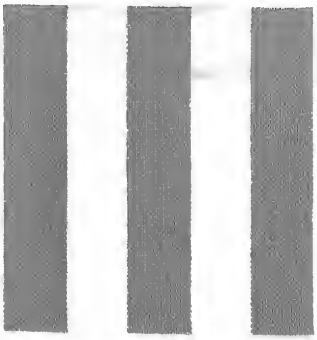
(See p. 56.)
No. 66 reduced 9 Lt.



(See p. 56.)
No. 67 reduced 1 Lt.



(See p. 56.)
No. 67 reduced 9 Lt.

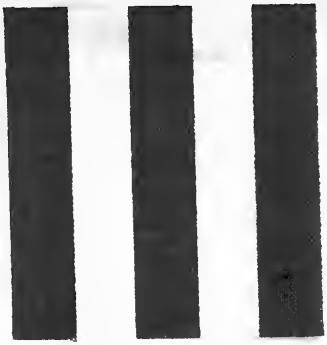


(See p. 57.)
No. 68.

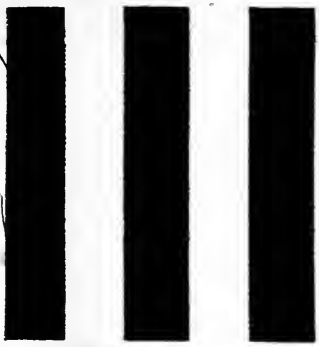
(See p. 57.)
No. 68 reduced 4 Lt.

PATTERN SHEET No. 17.

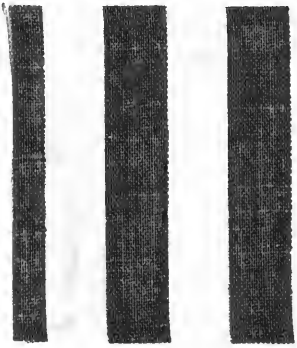
(See p. 57.)
No. 69 reduced 1 Lt. (light).



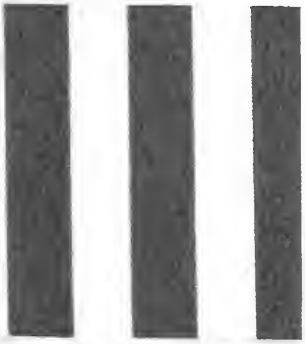
(See p. 57.)
No. 69 reduced 9 Lt.



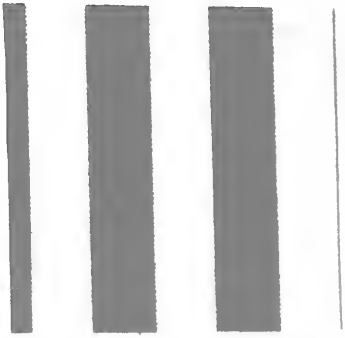
(See p. 57.)
No. 70 reduced 1 Lt.



(See p. 57.)
No. 70 reduced 9 Lt.



(See p. 66.)
No. 99.

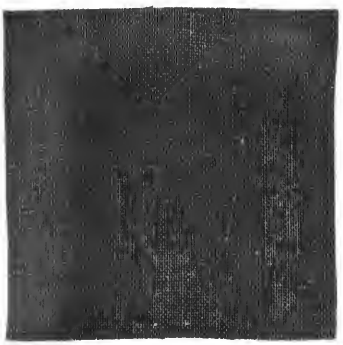


(See p. 66.)
No. 99 reduced 4 Lt.

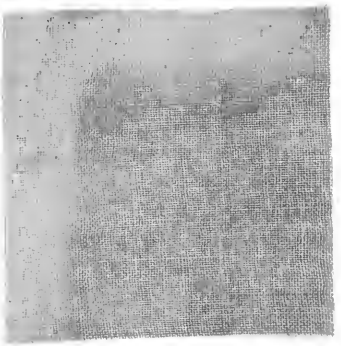
PATTERN SHEET No. 18.—Plain Shades.

(See p. 116.)
No. 1 Dark Indigo.

(See p. 116.)
No. 2 Light Indigo.



(See p. 116.)
No. 3 Dark Iron buff.



(See p. 116.)
No. 4 Light Iron buff.

(See p. 116.)
No. 5 Dark Prussian blue.

(See p. 116.)
No. 6 Light Prussian blue.

PATTERN SHEET No. 19.—Plain Shades.

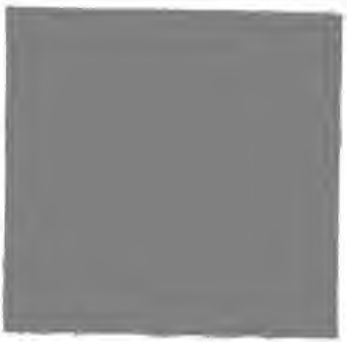
(See p. 117.)
No. 8 Catechu brown.

(See pp. 117 and 121.)
No. 8 topped with Chrysamine.

(See pp. 117 and 121.)
No. 8 topped with Benzo orange.

(See p. 121.)
No. 22 Direct red.

(See p. 121.)
No. 23 Direct blue.



(See p. 121.)
No. 24 Direct yellow.

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